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PSYCHOSOMATIC PROBLEMS IN MILITARY ORTHOPAEDIC SURGERY *

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World Wars I and II have given impetus to the study and understanding of the neuroses. Involvement of the musculoskeletal system by these disorders is more common in the Army than was formerly appreciated. Orthopaedic surgeons, as well as other clinical specialists, have come to the realization that there is a psychiatric aspect to their specialty which they can neither ignore nor deal with merely by intuition. Many have been so fascinated by the physical phase of the work that too little recognition has been given to psychosomatic problems,—even to the extent of carrying out heroic operative procedures upon neurotic patients.

To diagnose a syndrome as functional merely by methodically ruling out all known organic lesions is to disregard the fact that the psychosomatic entities have characteristics of their own. A psychosomatic diagnosis must be based upon what the patient has, and not alone upon what he has not. Of course, a complete search for organic lesions should not be neglected. We now recognize that, if musculoskeletal symptoms of psychogenic origin are identified, our responsibility to the patient does not always end when we have found that there is no organic lesion.

In discussing the frequency with which psychological problems are encountered in an Orthopaedic Section, Menninger[4] has said: ". . . every medical patient and every surgical patient has a psychological aspect to his illness". In a study of 450 consecutive cases on an Army Medical Service which were given diagnoses of arthritis or of allied organic conditions, Boland and Corr found "psychogenic rheumatism" to be the most frequent cause of disability. There may even be an important psychic factor in fractures and other accidents. Dunbar refers to accident proneness, and presents evidence that a personality factor is responsible for approximately 80 per cent. of accidents, leaving not more than 20 per cent. which are "accidental" accidents. A survey of all patients hospitalized on the Orthopaedic Section during the year 1943 disclosed that 11.1 per cent. had outstanding psychological problems which were either the sole cause, or the most important contributing cause, of their disabilities. Among the patients in the Orthopaedic Out-Patient Department during the same year, over 25 per cent. were predominantly psychogenic.

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Three types of psychological problems have regularly appeared in the Orthopaedic Section: (1) psychogenic problems in which no relevant organic lesion could be uncovered either in the present or in the past; (2) psychogenic problems which were secondary to organic lesions; and (3) psychogenic problems which perpetuated some of the physical symptoms of a healed organic lesion. From a psychiatric standpoint, the cases with psychogenic musculoskeletal symptoms may be divided into those with (a) conversion reactions, (b) anxiety or tension states, and (c) elaborations (psychogenic elaboration of symptoms from an organic lesion). Various combinations of these three types are more common than pure types.

Where there are concomitant functional and organic symptoms, every effort is made to determine the relative part each plays in the clinical picture, and therapy is directed toward each component. The need for recognition of the emotional factors associated with organic diseases is well stated by Weiss and English: "The day is near at hand for the final outmoding of the 'either-or' concept (either functional or organic) in diagnosis and to place in its stead the idea of how much of one and how much of the other, that is, how much of the problem is emotional and how much is physical".

More than 1,000 cases, in which the psychogenic factor was either the most important cause or the sole cause of musculoskeletal symptoms, were referred to the Orthopaedic Section. All cases were referred for orthopaedic diagnosis and treatment by physicians in dispensaries and in the various Clinical Sections of this and other Army Hospitals. By referring most cases with disabling musculoskeletal symptoms first to the orthopaedic surgeon, the complex cases which prove to be purely psychological problems may be quickly studied, recognized, shown to have no orthopaedic complications, and promptly transferred to the psychiatrist. This procedure gives the psychiatrist and the patient reassurance that there is no definite evidence of an organic lesion of the musculoskeletal system.

Not nearly all of the cases displaying functional musculoskeletal disability were diagnosed as psychoneuroses. Many were classified by the psychiatrists as cases of simple adult maladjustment; this meant in most instances that the patient had been adjusted emotionally for most of his life, but had now succumbed to overwhelming psychical stresses, usually incident to military service. Most of these patients recovered or improved under psychotherapy and environmental manipulation. Of the fully developed neuroses which were observed, the largest group revealed conversion phenomena in the form of pain, non-anatomical areas of hypalgesia, paralysis, or bizarre posture. An accurate classification by the psychiatrists as to type was frequently impossible, due to the mixture of symptoms. An element of anxiety was uncovered fairly regularly, but pure cases of anxiety neurosis have been in the minority. Neurasthenia, hypochondria, and compulsion neurosis were all observed in the Orthopaedic Section, but these findings were exceptional. No attempt will be made to give a detailed account of the psychiatric aspect of the cases studied, because the writer is not a psychiatrist. Rather, an attempt will be made to present those phases of the problem which are of interest to the physicians who treat musculoskeletal conditions. Surgeons have hesitated to depart from the "solid ground" of the soma to tread on the "thin ice" of the psyche, but there is increasing evidence that the day is approaching when they will freely discuss the psychological aspects of their surgical cases.

PSYCHOLOGICAL HISTORY

Menninger[3] has outlined an excellent abbreviated neuropsychiatric examination which can be conducted in a few minutes. The Adaptability Rating Military Aeronautics of the Army Air Forces Flight Surgeons includes a similar examination. This type of abbreviated history is taken on all cases in the Orthopaedic Section in which the source of symptoms is obscure, or in which inadequate objective and laboratory evidence exists to explain the subjective symptoms. The long, comprehensive history taken by the psychiatrist requires

considerable time and experience; such a study is essential only for the understanding and evaluation of complex cases. An abbreviated psychological history can be taken by any physician in conjunction with the regular clinical history, and in a high percentage of instances it will give sufficient information for an adequate evaluation. After such a study a psychological disorder will not often be perpetuated by being treated as an organic entity, or denied therapy because no organic lesion is identified.

In dealing with soldiers, one of the first questions in a psychological history regards adjustment to military life. Many factors in Army service cause anxiety, and in the emotionally immature individual this growing anxiety can precipitate neurotic physical symptoms. Neurotic symptoms very often develop in soldiers with poor psychical resistance during the first few months of service, before combat conditions are encountered. These soldiers cannot withstand regimentation and steady, hard, monotonous work, in addition to being denied their home life, luxuries, and old friends. Their despair and resentment give rise to frustration and conflicts, which usher in mental depression and disturbed sleep. Sleeplessness and long hours of hard work soon lead to chronic fatigue, increased insomnia, and more anxiety. The soldier may then meet an adverse situation which is "the straw that broke the camel's back" and may dramatically convert his emotional chaos into physical symptoms; if these symptoms are manifest in the musculoskeletal system, he will probably be sent to an Orthopaedic Section. In a psychological history it is important to record a previous nervous breakdown of the patient or of a member of his family. An unhappy, loveless childhood is also given the greatest significance by psychiatrists. Inability to work, to go to school steadily, or to get along well with people usually indicates maladjustment, and such findings are frequent in the neuroses. Excessive fatigue, insomnia, nightmares, nervous tension, globus hystericus, palpitation of the heart, hyperhidrosis, eneuresis, physical and mental depression, vertigo, fainting, numbness and tingling of the extremities, timidity, sexual perversions, sulkiness, laziness, tantrums, and seclusiveness may all be of psychological origin. A history of one or several of these symptoms may indicate the presence of an important emotional problem, and may throw light on the patient's emotional maturity.

SUBJECTIVE FINDINGS

Psychogenic Pain in the Musculoskeletal System

It is enlightening, and most helpful from the standpoint of diagnosis, to persuade the neurotic patient to describe his symptoms accurately. At the outset he usually describes his physical distress merely as a pain, just as does the patient with an organic lesion. There are important shades of difference between organic and psychogenic pain, and these differences may serve as useful clues to the correct interpretation of the entity at hand. It must be emphasized, however, that one is not justified in basing a diagnosis of a functional disorder solely upon any one symptom in the clinical picture, regardless of how significant that symptom may appear.

What the neurotic individual describes as pain in the joints or in other regions may be discovered, upon further questioning, to be a feeling of tension or of pressure. The region may feel tight and the tension may increase steadily when the part is kept in one position. Such tension may be described as a "pulling sensation", and may be associated with throbbing. The focus of psychogenic distress may feel as though a great weight were upon it, and as though the area were intensely fatigued. Peculiar and bizarre postures may be assumed, such as forward flexion of the spine (camptocormia). There is no position of complete relief, and no relief is obtained from immobilization. In a normal-appearing joint, a psychogenic factor should be suspected when a disabling pain is not influenced by motion or rest of the joint. An occasional patient is considerably relieved by bed rest, and appears willing to spend many months in the hospital. When in bed he escapes from part

of his anxiety, and is thereby partially relieved of the physical manifestations of the anxiety.

Bizarre patterns of radiating pain may also characterize a neurosis. One of the most consistently psychogenic pains is that which radiates from the coccyx or sacral region up the spine, to end in the upper back or in the occipital region. Pain radiating from a distal point proximally is far more likely to be of functional origin than pain which radiates distalward.

Reaction to Procaine

A distorted or paradoxical reaction to procaine, injected into a site of musculoskeletal pain, is often a clue to a psychological disorder.

Other Complaints

Other complaints, some of which may occur with purely organic lesions, may be associated with the neuroses. These include sensations of numbness and of "pins and needles" in the extremities, which feel as though the arms and legs are asleep; compelling impulses to change position continually in order to prevent the legs from becoming unbearably tense or "dead"; daily variation in the site or sites of discomfort; the feeling that a part of the body is missing, particularly the extremities; inability to relax a portion of the body; and diffuse weakness of an extremity.

OBJECTIVE FINDINGS

The physical examination may reveal no positive findings, or it may disclose many. The objective findings most frequently observed in association with psychological disorders are: (1) circumferential (non-anatomical) hypalgesia; (2) hysterical paralysis; (3) vasomotor instability; (4) hyperhidrosis; (5) hyperactive reflexes; (6) camptocormia and other psychogenic postures; (7) astasia-abasia (ability to sit and move about in bed, but not to stand or walk); (8) coarse intention tremor of an extremity; (9) anxiety symptoms (apprehension, frustration, bounding pulse, and dilated pupils); and (10) blindness, deafness, aphasia, or aphonia. Again it must be emphasized that a clinical picture is not necessarily considered psychogenic merely because one of the above findings is present. The diagnosis is made after weighing each subjective symptom and objective finding, and analyzing the picture as a whole.

Circumferential Hypalgesia ("Stocking-and-Glove" Anaesthesia)

One of the most significant objective evidences of a neurosis, and one which is frequently overlooked, is the presence of non-anatomical areas of diminished sensation. Such areas are nearly always circumferential, and they involve extremities more frequently than other parts of the body. However, the patterns of distribution appear to be legion. A detailed study was made of 100 consecutive cases in which conversion reactions included circumferential hypalgesia (Figs. 1 to 4). At the bottom of each sketch, below the soldier's rank, initials, and age, is a statement of the major site of the subjective musculoskeletal symptoms. All cases having similar subjective complaints are grouped together. It is at once apparent that the site of musculoskeletal symptoms did not often dictate the pattern of the hypalgesia. Neurotic hypalgesia may be associated with functional subjective symptoms in other body systems, particularly the cardio-respiratory and gastro-intestinal systems, and the patterns of hypalgesia are similar to those observed when the functional symptoms are centered in the musculoskeletal system. Ten of the 100 patients had hysterical paralysis, and in each instance the paralysis was at the site of pain.

Although conversion hysteria seldom produces analgesia and anaesthesia, it frequently is associated with hypalgesia and hypaesthesia. Since the diminished response to the

sensation of pain is relative, the line of demarcation between the site of the patient's normal response and the site of his diminished response must be identified. This can be done only by carrying out an examination which tests every one or two inches of skin, along lines running the length of the entire body. A sharp pointed instrument, such as a pin or needle, is used, and the skin is pricked quickly, sharply, and firmly. An accurate interpretation of abnormal pain sensation can be made only when the examiner knows what constitutes a normal response in the various regions of the body. To have a clearer idea of the normal response, complete sensory examinations were done on 400 individuals with no known physical or mental disorders. There is considerable variation in the normal response, but certain regions are consistently more sensitive to pinprick than others. The more sensitive areas include the palms and the volar aspect of the fingers, the antecubital region, the axilla, eyelids, lips, groins, genitalia, popliteal regions, and the soles of the feet. The medial aspect of the arm is more sensitive than the lateral aspect, the temporal regions are more sensitive than the top of the head, and most of the face is more sensitive than the neck.

During the examination, information can often be gained simply by watching the patient's response, rather than by asking him to state whether the pinprick feels sharp or dull. If there is hypalgesia of a part, the patient will nearly always flinch sharply when normal sensation is encountered at the line of demarcation. If no flinching occurs, the patient is asked whether there is a sudden change in the way he feels the pinpricks. Every effort is made to avoid suggesting a response to the patient. The temptation to mark levels with a skin pencil should be resisted, and to discuss hypalgesia patterns with the neurotic patient serves only to increase his burden of anxiety. It is unusual for the patient himself to discover the hypalgesia.

In many cases the regions of hypalgesia were tested for their response to touch, heat, and cold. In the involved areas there was a consistent diminution in the patient's reaction to all forms of sensory stimuli, but no test is so striking nor so satisfactory for identifying levels of demarcation as that for pain sensation. In areas of neurotic hypalgesia, the diminished pain sensation involves the deep structures to the same degree as it does the skin. This is particularly evident when needles are inserted without pain into the periosteum, the ligaments, and the joint capsules. Compression of these structures is also painless, and this fact is most striking when the tendo achillis or the pretibial periosteum is firmly compressed without producing pain. Compression of the heel cord and pretibial compression can be employed in the lower extremities, in addition to the sensory check. In the upper extremities, finger-tip or carpal compression serves the same purpose.

Numerous patients showing hysterical hypalgesia were examined on several occasions to determine the course of the sensory changes. In a few cases the changes entirely disappeared in from two to ten days, but in most instances the changes lasted several weeks and persisted at least as long as the pain and distress. Several cases that were followed through more than one episode of conversion symptoms disclosed sensory changes during each episode, and were entirely free of such changes between episodes. It was not unusual for the pattern of hypalgesia to change, sometimes radically, but most cases showed a consistent pattern and unchanging levels. In studying the sharpness of the demarcation, it was common to find that as little as one-quarter of an inch separated the zone of hypalgesia from the zone of normal sensation.

The medical literature includes few descriptions of the variations in distribution and the characteristics of hysterical sensory changes, and it is for this reason that the patterns of 100 cases showing these changes are presented. This is a relatively large series to be screened from a non-psychiatric section, but many thousands of cases were studied and treated in the Orthopaedic Section during a period of approximately two years.

Of the 100 patterns, ninety showed multiple sites of hypalgesia and seventy-two had some degree of involvement of all four extremities. Changes were confined to the right

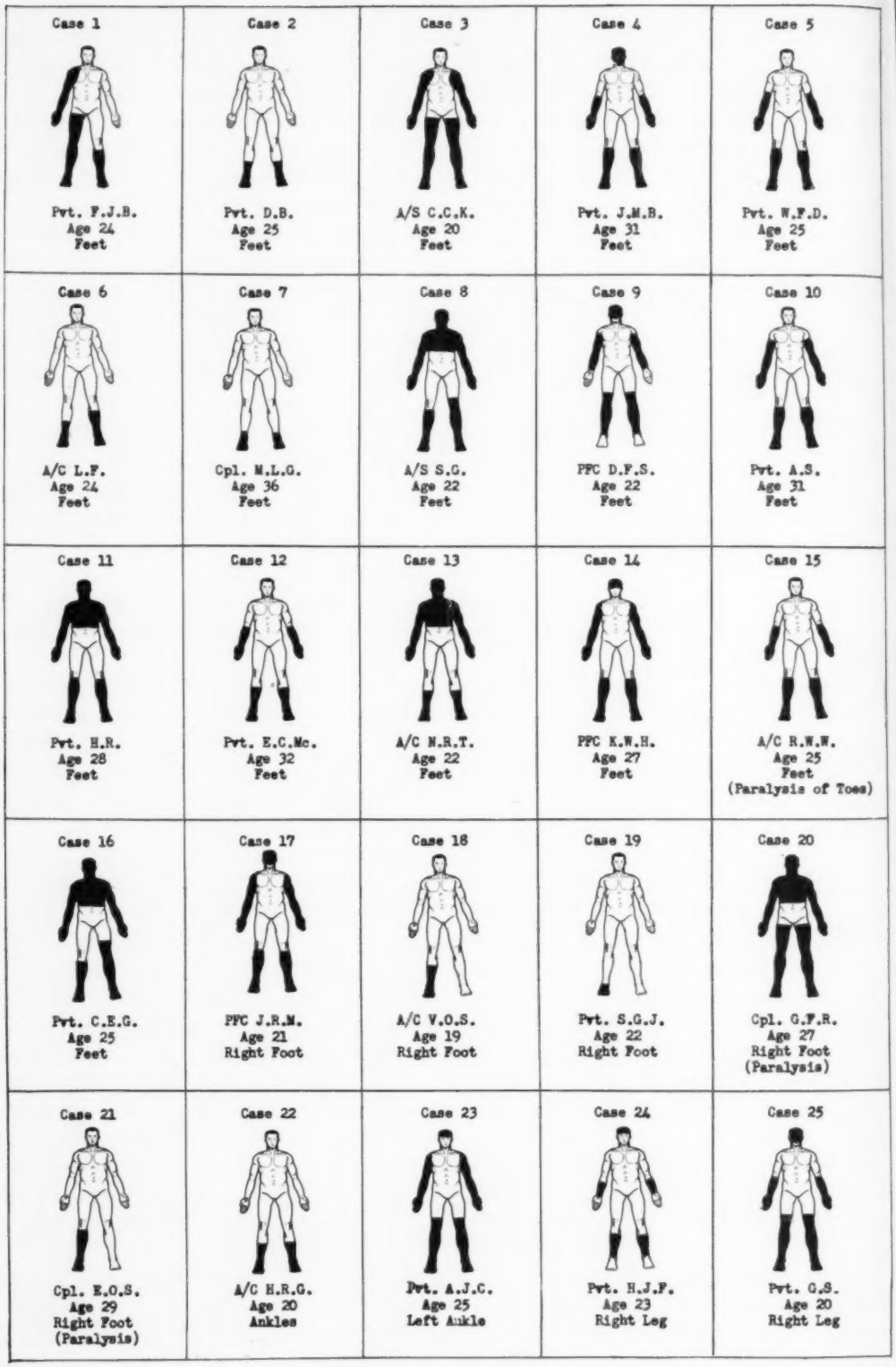

FIG. 1

Distribution of non-anatomical areas of hypalgesia in cases of conversion hysteria. The predominant site of subjective symptoms is stated beneath the patient's age.

Case 26 Pvt. C.M.T. Age 28 Right Knee (Paralysis)	Case 27 Pvt. M.K.B. Age 27 Right Knee	Case 28 A/C E.C. Age 24 Right Knee	Case 29 Pvt. J.B.C. Age 28 Right Knee	Case 30 A/C D.N.D. Age 26 Right Knee
Case 31 Pvt. F.C. Age 19 Right Knee	Case 32 Pvt. S.M.G. Age 34 Right Knee	Case 33 A/C R.S. Age 19 Right Knee	Case 34 Pvt. R.C.P. Age 22 Right Knee	Case 35 Pvt. L.R. Age 29 Right Knee
Case 36 Pvt. E.A.J. Age 23 Right Knee	Case 37 Cpl. L.A. Age 26 Right Knee	Case 38 A/C R.M.Mc. Age 20 Right Knee	Case 39 Pvt. W.E.M. Age 21 Right Knee	Case 40 2nd Lt. W.C.B. Age 24 Right Knee
Case 41 Pvt. J.V.P. Age 21 Left Knee	Case 42 Pvt. W.S.C. Age 31 Left Knee	Case 43 A/C F.H.W. Age 22 Left Knee	Case 44 A/C E.W.T. Age 21 Left Knee	Case 45 A/C O.J.S. Knees
Case 46 Pvt. H.J.S. Age 32 Right Thigh (Paralysis)	Case 47 Pvt. J.P. Age 36 Right Thigh and Leg	Case 48 A/C W.N.L. Age 21 Right Thigh	Case 49 Pvt. W.G.W. Age 29 Right Leg and Thigh (Paralysis)	Case 50 Sgt. L.M. Age 24 Coccyx

FIG. 2

Patterns of circumferential hypalgesia.

side of the body in eleven cases, and to the left side in four. In fifty-two cases part or all of the head was involved; this included the conjunctiva, when the level extended below the eyes. While the site of the musculoskeletal symptoms did not often appear to dictate the pattern of the sensory changes, all cases in this series which had extremity symptoms had hypalgesia in those extremities. There was a tendency for unilateral symptoms to be on the right side. Of the nineteen cases with unilateral knee symptoms, fifteen were on the right and only four on the left. Of the five cases with symptoms in one foot, all were on the right.

Sixty-eight of the patients were enlisted men, thirty-one were aviation students and cadets, and one was an officer. In the ten cases of hysterical paralysis the involvement was in the extremities, and was distributed as follows: toes, one case; right foot, two cases; right knee, one case; right leg and thigh, one case; right thigh, one case; left shoulder, two cases; left forearm, one case; right forearm, one case. Of these cases, four were of short duration and responded well to treatment; six were of many months' duration and were resistant to therapy.

COMPARISON OF PSYCHOGENIC AND ORGANIC MUSCULOSKELETAL SYMPTOMS

Since the majority of psychogenic musculoskeletal symptoms are referred to joints, emphasis will be placed upon differential joint diagnosis.

When the physical symptoms are out of proportion to the objective findings, the possibility of a psychogenic disorder must be entertained. In the majority of cases in this series with joint symptoms, there were no positive objective findings. A roentgenogram of the joints was usually made, however, and a sedimentation rate was obtained to make certain that no organic lesion was developing and to reassure both the doctor and the patient. Diffuse tenderness is not an unusual psychogenic symptom. This type of tenderness is not limited to anatomical structures, however, and may vary in its distribution from day to day. It may involve the entire back or an entire extremity. Those regions of the body which are normally quite tender must not be recorded as sites of point tenderness.

Muscle spasm may unconsciously be simulated by the neurotic individual, who may hold a part of his body in one position for a long period of time: the knees may be held rigidly extended, the foot in equinus, the spine bent forward, the head bent to one side, or a shoulder elevated. In these cases the joints may become stiff and the muscles atrophied, thus presenting a secondary organic problem.

In psychogenic disorders, when a joint is flexed passively, resistance may be encountered after the first few degrees of motion and the patient may state that he cannot move the joint farther. However, if a steady, firm pressure is employed, the joint will usually continue to flex, and usually will proceed slowly and jerkily to the normal degree of flexion. In striking contrast is the finding in joints having organic lesions. When substantial resistance and pain are met during the process of flexing the joint, there is progressive muscle spasm; and only rarely can the patient tolerate having the joint flexed beyond a few more degrees.

Radiating pains, with a consistent anatomical pattern of distribution in one extremity, are likely to be organic. Bizarre pains, radiating simultaneously into two or more extremities or up the spine and presenting changeable patterns, have usually proved to be psychogenic. A steady, firm resistance offered by some neurotic patients to all passive movements of the lower extremity should not be mistaken for positive leg signs. Line tenderness of the type that occurs along an inflamed nerve trunk—for example, the sciatic nerve—is not likely to be simulated by a psychogenic problem. An entire extremity may become tender on a psychogenic basis, however, and if only a nerve trunk or other solitary structure is palpated, a misinterpretation might follow.

Vasomotor disturbances may become pronounced in the neurotic patient. It is a frequent complaint that a part of the body, usually an extremity, is cold and "dead" for want of good circulation. If symptoms are entirely on a neurotic basis, the circulation, except for vasomotor instability, would be found to be unaltered.

Differentiation of organic from hysterical paralysis may be difficult. In many instances a psychogenic paralysis develops immediately after an accident and may resemble a serious nerve or brain injury. Hysterical paralysis may be either flaccid or spastic, but the flaccid type is more common. Its response to psychotherapy, faradic stimulation, or narcosynthesis may be spectacular. Hysterical paralysis, like hysterical hypalgesia, is bizarre and non-anatomical in pattern. The many tests for identifying localized nerve injuries are useful in differential diagnosis, but need not be reviewed here.

It is a mistake to assume that muscle atrophy cannot occur in hysterical paralysis; definite atrophy of all structures in entire extremities may occur, and may lead to organic changes which pose many orthopaedic problems.

Subjectively, there are important differences between organic and psychogenic musculoskeletal symptoms, which deserve emphasis. The exact time of onset and the character of psychogenic conditions are often vague, but frequently they are related to a period of great emotional stress. Recurring episodes of symptoms over a period of years, beginning in childhood or early adult life, is the rule in conversion hysteria. It is impressive to examine a joint, or any other part of the musculoskeletal system which is claimed to have been the source of much distress and disability for many years, and to find no objective evidence of disease on physical examination or by laboratory test. In such instances an examiner may visualize some unfamiliar deep-seated musculoskeletal disease process. It is commendable to search diligently for organic lesions; but a tiny marginal osteophyte, a slight malalignment of a joint, or a minor congenital anomaly has been held up all too often as the etiology of purely neurotic musculoskeletal symptoms.

That a minor as well as a major organic lesion can precipitate a neurosis is frequently observed. The neurotic patient often begins his story by telling about a sprained ankle, a back strain, or a "twisted knee". He may ascribe all of his subsequent troubles to this organic lesion, which usually healed promptly and left no organic evidence. These individuals have usually tried a wide variety of orthopaedic procedures, which are despairingly described as having offered no lasting benefit. The treatments received during episodes of neurotic musculoskeletal symptoms are given some credit, and this is particularly true of that therapy in use toward the end of one or more episodes. These patients, so trying to organicists, refuse to remain "cured". Each period of emotional chaos in their lives ushers in an episode of neurotic somatic symptoms.

There is an important group of "orthopaedic neurotics" who have both a serious organic disability and a complex psychogenic musculoskeletal disorder, and they may present difficult problems in diagnosis and therapy. The psychogenic and organic symptoms overlap in such a way as to make it impossible on occasions to know where the organic ends and the psychogenic begins. Our attempts at a rigid separation of these two sources of symptoms are, however, not always warranted. Abnormal physiological and psychological responses go hand in hand. Psychosomatic medicine is not a new kind of medicine, but medicine in a wider perspective. From a practical standpoint, however, we must very often separate the organic from the psychological in order to institute proper treatment. Both types of symptoms must be treated simultaneously and each must be given its deserved quota of attention.

During episodes of acute, painful, disabling organic disease—particularly if the patient is bedfast—neurotic symptoms may be minimal. If, during the convalescent period, the patient is permitted to spend endless hours in introspection, the neurotic element becomes dominant. If unrecognized, unappreciated, and untreated, the stage may then be set for months, years, or even a lifetime of disability.

Case 51 Sgt. B.E.C. Age 23 Coccyx	Case 52 A/C G.H.P. Age 22 Coccyx	Case 53 Pvt. C.R. Age 35 Coccyx	Case 54 PFC M.C.J. Age 28 Coccyx	Case 55 PFC J.E.M. Age 34 Coccyx
Case 56 A/C W.C.P. Age 19 Coccyx	Case 57 Pvt. G.A.W. Age 25 Coccyx	Case 58 A/C J.E.B. Age 24 Low Back	Case 59 Cpl. J.A.S. Age 27 Low Back	Case 60 A/C I.J.B. Age 23 Low Back
Case 61 PFC M.E.B. Age 24 Low Back	Case 62 Sgt. L.G.C. Age 24 Low Back	Case 63 PFC J.H.C. Age 37 Low Back	Case 64 A/C R.H.C. Age 22 Low Back	Case 65 Cpl. M.G. Age 33 Low Back
Case 66 Sgt. R.L. Age 33 Low Back	Case 67 PFC L.R. Age 25 Low Back	Case 68 Pvt. K.H. Age 22 Low Back	Case 69 Sgt. S.N. Age 28 Low Back	Case 70 M/Sgt. D.S. Age 45 Low Back
Case 71 A/S F.C.M. Age 20 Low Back	Case 72 A/C N.M. Age 25 Low Back	Case 73 Pvt. R.W.W. Age 23 Low Back	Case 74 A/S F.A. Age 26 Low Back	Case 75 PFC F.J.M. Age 36 Low Back

FIG. 3

Patterns of circumferential hypalgesia.

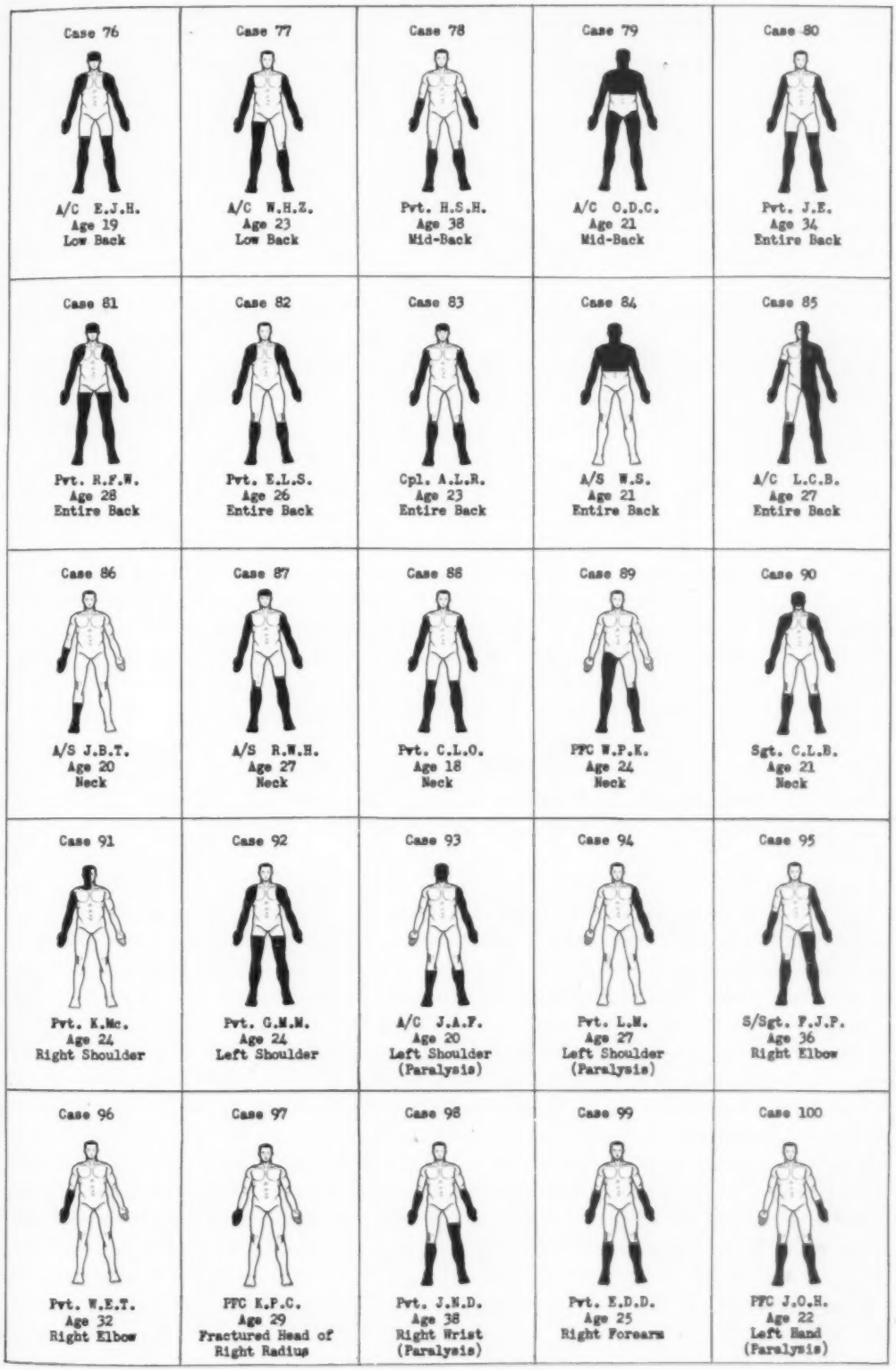

FIG. 4

Patterns of circumferential hypalgesia.

Sites of Neurotic Musculoskeletal Symptoms

Although no part of the body is exempt, certain sites in the musculoskeletal system are particularly apt to become foci of neurotic symptoms. Such sites are the sacral region, the coccyx, knees, feet, neck, and shoulders. The site of a healed fracture, particularly if associated with a skin scar, is often the focus of neurotic symptoms.

Although in some instances it is impossible to uncover any explanation of the particular site in the musculoskeletal system at which the symptoms occur, in a high percentage of cases combined orthopaedic and psychological histories will identify the focus as the site of previous organic symptoms, either in the patient himself or in someone close to him,—for example, a mother, father, or brother. Psychogenic symptoms frequently appear during convalescence from an organic musculoskeletal lesion, and may tend to simulate the previous organic symptoms, thereby perpetuating much of the original disability for weeks or years after the organic lesion has healed. After experiencing a frightening accident and simultaneously incurring major or minor musculoskeletal lesions, the patient may periodically relive the experience and the musculoskeletal symptoms, as a neurotic manifestation.

THERAPY AND DISPOSITION

The psychiatrists can care for the complex psychological problems, but for a large group of patients, particularly those with combined psychogenic and organic musculoskeletal symptoms, the orthopaedic surgeon will have to assume responsibility for the psychotherapy. Just as there is an acceptable abbreviated form of psychological history, there is also worth-while abbreviated psychological therapy, referred to as superficial or minor psychotherapy. This form of therapy includes evaluation and advice regarding correction of environmental conflicts; the giving of insight into the significance and the character of the existing psychological symptoms, and the explanation of any coexistent organic symptoms; identification and elimination of the underlying conflict, when possible, and when not possible the elimination of aggravating factors; administration of sedatives for insomnia or for chronic fatigue; and the prescription of occupational therapy when indicated.

In setting the stage for psychotherapy, it is of the utmost importance that the physician have the proper attitude toward the patient's psychological problem. To treat neurotic and maladjusted individuals as though they were weaklings or malingerers is to slam the door upon psychotherapy. The necessity for gaining the patient's confidence, prior to attempting psychotherapy, is self-evident. Psychiatrists refer to this as establishing rapport.

Psychological disorders uselessly dissipate the patient's energy. If the amount of energy lost is slight or moderate, the patient may be able to live an approximately normal life. Under this circumstance he may be considered as emotionally compensated. If additional emotional stress is incurred, he not only needlessly dissipates more of his energy, but may transform his emotional chaos into physical symptoms, and then may be said to be in a decompensated stage. Ordinarily such patients can be brought back to their previous state by such relatively simple measures as correcting an environmental conflict. The neurotic individual may be forced to lead a protected, carefully regulated life in order to remain "compensated". Those who cannot be cured must be taught to live with their neuroses. It has been gratifying to find that many soldiers who were weighed down by fixed neuroses have been able to carry on after they have been helped to solve some of their environmental problems. Their psychogenic musculoskeletal symptoms have not always subsided, but frequently have diminished to the extent that the patient could do his job.

Response to treatment depends upon many factors. Some patients develop symptoms

only under the most profound mental and physical stress. In such patients the response to treatment and the prognosis are better than in individuals who develop neurotic episodes under the ordinary stresses of life. The term "threshold of conversion" may be used to visualize the transformation of emotional disturbances to physical symptoms. Just as individuals have a different threshold of pain, they also have a different threshold at which they are overwhelmed by psychological stresses. Experiences in this War have taught psychiatrists that even the hardiest soldier has a breaking point and will become a psychological casualty, if the pressure becomes sufficiently great and prolonged. In this type of case the good response to early treatment and the good prognosis are in striking contrast to conditions found when there is a low threshold of conversion.

Very often there is both organic and psychogenic musculoskeletal pain, and progress in psychotherapy may be retarded or postponed until the organic lesion has been recognized and treated successfully. Analgesics which relieve the organic pain and have little effect on the psychogenic pain may be helpful in evaluating the extent of the organic symptoms.

Neuroses secondary to and precipitated by organic lesions can often be prevented. A patient should not be told that his illness or injuries are serious and may result in permanent disability until there is no doubt that it is true. Bad news, true or false, can damage the patient's mental health.

As far as possible, patients with neurotic musculoskeletal symptoms are treated in the dispensaries in order to keep hospital admissions to a minimum. Neurotic patients admitted to the Orthopaedic Section are studied as rapidly as possible to rule out organic lesions, and disposition is made without delay. Before he is released, the patient is firmly and positively reassured that no musculoskeletal organic lesion is producing his symptoms.

Prior to doing elective major surgery, a psychological evaluation of the patient should be obtained. As Wechsler has said in referring to unwarranted surgery: "Heroic operations do violence to patients and confirm their neuroses".

During convalescence an effort should be made to detect and correct bad psychological trends. By personally visiting the patient at close intervals, such trends can either be prevented or can be discovered early and treated. Keeping the patient well informed as to his condition, and reassured when progress is slow, does much to prevent psychological symptoms.

Of profound importance is the necessity for keeping the patient's mind and body as busily occupied as is feasible during convalescence. Menninger[5] has emphasized that: "Morbid preoccupation, and monotonous, empty days in a hospital extend and increase mental disability". The splendid convalescent training programs of the Armed Services have been of inestimable value in preventing psychological disorders during convalescence.

The most effective time to treat emotional problems is in their incipiency. In caring for flying personnel, flight surgeons do excellent work in both the prevention and the early treatment of psychological problems. They have long appreciated the importance of good mental health.

It is not enough to tell the neurotic patient that he has a neurosis and should snap out of it. His will power is not great enough to overcome his problem, so long as he does not have insight into the nature of the problem and the character of his symptoms. Giving the patient insight is best deferred until a thorough study of his condition has been made, and his confidence has been secured.

In the presence of anxiety, insomnia, and chronic fatigue, temporary administration of the barbiturates frequently plays an important part. Conflicts and frustration often follow in the wake of long-standing fatigue. Many an anxiety or hysterical state has been prevented by the judicious use of the barbiturates.

Aggressiveness in attaining relief often leads the neurotic patient to accept unscientific therapy, particularly if he is assured that he has an organic lesion underlying his symp-

toms. Except when neuroses are hopelessly fixed, palliative therapy, such as periodic body manipulations or pink pills, is condemned. To treat a disorder as physical when it is psychical can do much harm.

Whenever an environmental conflict aggravates or precipitates an emotional problem, an effort should be made either to alter the environment or the patient's attitude toward it. Reassignment helps many soldiers. Many neurotic individuals are capable of doing important work, if properly handled. Another trial of duty is indicated whenever there is any doubt as to the necessity for separating a soldier from the Service. Patients are urged to carry on and are firmly informed that their work will do their musculoskeletal systems no harm; rather, giving in to every symptom is the real source of harm.

In the past we have usually leaned far to the organicist's approach; we must not now lean too far the other way. In the words of Portis: "One cannot warn too emphatically against making the psychotherapeutic approach a new panacea for all patients".

ILLUSTRATIVE CASES

Case 7—Corporal M. L. G., aged thirty-six. The patient had had painful feet for many years, but they became much worse after he entered the Army. He had a "snowshoe" gait. No relief was obtained from supports or corrective shoes. The feet felt numb and stiff. There was normal mobility of all joints, also good mechanics. There was no tenderness or muscle spasm. Hypalgesia was limited to the feet and ankles. The patient made a very poor adjustment to the Army; a diagnosis of conversion reaction was made by the psychiatrist.

Case 21—Corporal E. O. S., aged twenty-nine. The patient sprained his right ankle in June 1942, and in two weeks was able to walk well. There were no unusual findings; roentgenograms were negative. Increasing pain then developed in the ankle and foot, and crutches became necessary. Paralysis of the foot followed. At six different hospitals the patient received many forms of physical therapy, casts, splints, and a brace. Physical examination disclosed normal bones and joints. There was partial flaccid paralysis of the right leg. The foot was held in plantar flexion and inversion. There was hypalgesia of the right leg, ending sharply at the knee. The patient responded to psychotherapy and faradic stimulation. A psychiatric examination revealed emotional immaturity, conversion reaction, and hysterical paralysis.

Case 23—Private A. J. C., aged twenty-five. At the age of nine the patient was frightened by a razorback hog and incurred a sprained left ankle. Periodically since, during periods of nervous strain, there had been disabling pain in the ankle and inability to stand or walk more than briefly. The ankle was said to feel tense and not under complete control. The left ankle was normal clinically and by roentgenogram. Hypalgesia was present in all four extremities and in the scalp. There was no evidence that the site of the subjective symptoms dictated this particular distribution of hypalgesia. The patient relives his original experience when under emotional stress.

Case 26—Private C. M. T., aged twenty-eight. Pain in the right shin, from knee to above ankle, was a complaint during activity. The patient described the pain as being like pegs driven into his shin. He walked with a stiff right knee and a hobbled gait. There was no evidence of an organic lesion. The psychiatric report described a "ceremonial" gait. There were many neurotic traits. The hypalgesia was not limited to the right leg, but involved all four extremities. An hysterical spastic paralysis held the right knee fixed in extension.

Case 28—Aviation Cadet E. C., aged twenty-four. The patient twisted his right knee in a broad jump and split the right medial meniscus. A bucket-handle type of torn medial meniscus was removed in its entirety. Convalescence was uneventful and the patient was cooperative. Upon return to duty many bizarre symptoms appeared in the right knee (numbness, throbbing, tingling, and a sense of "giving way"). Examination of the knee disclosed normal motion and stability, no swelling, and excellent musculature. The patient was eliminated as a cadet. He improved under reassurance and reassignment. The psychological examination disclosed a deep-seated fear of flying.

Case 32—Private S. M. G., aged thirty-four. The patient had had frequent episodes of pain in his right knee for seventeen years. There was no limitation of motion and no instability. Part of the right tibial tubercle was removed in 1942 for unhealed Osgood-Schlatter's disease. No relief was obtained from the operation, from numerous subsequent casts, or from physical therapy. There was never any locking of the knee, but many bizarre symptoms. Examination was entirely negative, except for hypalgesia, involving all of the extremities and most of the head. Further surgery, casts, or physical therapy would probably have aggravated and further fixed this patient's conversion reaction. A psychiatric

history indicated that this soldier had made an unsatisfactory adjustment to his environment since childhood.

CASE 41—Private J. V. P., aged twenty-one. A torn medial meniscus was removed from the left knee after three years of symptoms. Convalescence was uneventful until it was time to return to duty. Pain, weakness, and stiffness in the knee then developed. The patient could not keep his knee in one position more than a few minutes, because it would "go to sleep" and feel dead. He also complained of hyperhidrosis and insomnia. The patient was reclassified and given ground duty. Hypalgesia was present, as shown in Figure 2. The soldier had an anxiety state, which subsided after superficial psychotherapy.

CASE 44—Aviation Cadet E. W. T., aged twenty-one. Three months after removal of a torn left medial meniscus, weakness in the left knee suddenly developed, and the patient was unable to walk. A locked knee was simulated, and an exploration was recommended by the ward officer. Examination revealed diffuse weakness of the entire extremity and hypalgesia to the level of the iliac crest. Further study disclosed emotional instability, "nervous spells", and somnambulism. The patient's father had had several "nervous breakdowns". The knee symptoms subsided with psychotherapy. The soldier was discharged from Service by advice of the Psychiatric Section, due to pronounced emotional instability and neurotic background.

CASE 55—Private First Class J. E. M., aged thirty-four (actor). The patient complained of pain in the coccyx and in the left side of the back, from sacrum to neck. The symptoms had been present for six years, since a fall down several steps at a motion-picture studio. There was frequent tingling and numbness of the entire left side of the body. Sleep was disturbed, and the patient had no energy. There was left hemiplegic hypalgesia. Anxiety symptoms and a conversion reaction were combined in this case. The patient was a failure both as an actor and as a soldier, and had a poor capacity for adjustment to adult life.

CASE 65—Corporal M. G., aged thirty-three (musician). Pain in the lower back, radiating down both lower extremities posteriorly to the ankles, had been present since a fall during a handball game in 1934. The patient had had innumerable types of therapy, except psychotherapy. Belts and casts increased the back pain and produced abdominal pains. The patient was tense, "nervous", and irritable most of the time. Back pain was precipitated by episodes of "nervousness". He was unable to stand or to sit long in any one position. Physical examination and roentgenograms of the spine were negative. Hypalgesia was present in all extremities, as shown in Figure 3. There were numerous neurotic traits, dating back to childhood. There was no response to psychotherapy.

CASE 74—Aviation Student F. A., aged twenty-six. Low-back pain developed soon after the patient entered the Army, eighteen months prior to Hospital admission. The pain radiated "down both the bones" of the thighs to the knees. He had camptocormia, which became pronounced during hospitalization. The condition was treated for several weeks as a lumbosacral strain, during which time all symptoms were aggravated. Roentgenograms were negative. Hypalgesia was present, as shown in Figure 3. There was normal mobility of the spine. Response to a brief period of psychotherapy was poor.

CASE 88—Private C. L. O., aged eighteen (negro). The patient fell off a cotton bale in 1941, landing on his head. No serious injury resulted, but the neck was moderately painful and he experienced a "lump in the throat" for several days. He continued to have pain and "popping" in his neck; the pains would radiate up the neck and over the top of the head, to end in his eyes. There were frequent episodes of "nervousness", during which the globus hystericus would return and the neck pain would reappear. The patient had constant fatigue, and could do only light work. He had been told that he had arthritis, and this caused him much worry. Roentgenograms were negative and there was normal mobility of the cervical spine. The patient had the emotional maturity of a child. Hypalgesia was present in all four extremities, but failed to involve the neck or any part of the head.

CASE 93—Aviation Cadet J. A. F., aged twenty. The patient had difficulty with his studies and many fears about flying. He was in a constant state of nervous tension, gradually became exhausted, and could not sleep. An acute anxiety state suddenly developed, during which there was diffuse pronounced weakness and aching of the entire left upper extremity. He complained of a spot on the scalp, the size of a silver dollar, that burned and frequently "felt like it would explode". There was pronounced intention tremor of the left upper extremity. There was hypalgesia of left upper extremity, legs, and head, as shown in Figure 4. No orthopaedic or organic neurological abnormality was found. The patient was promptly transferred to the Psychiatric Section, where he was soon relieved of the anxiety state and hysterical paralysis by psychotherapy.

CASE 98—Private J. N. D., aged thirty-eight. The patient complained of pain and weakness of the shoulders, arms, and entire spine for twelve years. All symptoms increased during twelve months of Army service. He had a permanent Kitchen Police assignment. Ten days prior to admission to the Hospital, while peeling potatoes, the patient's right hand suddenly became paralyzed. There was normal finger and thumb action, but all ability to extend the wrist was lost. No orthopaedic or neurological

problem could be identified. The patient responded to psychotherapy. His intellectual and emotional maturity were those of a ten-year-old child.

SUMMARY AND CONCLUSIONS

1. There is a psychiatric aspect to orthopaedic surgery which should receive increased recognition.

2. A psychosomatic diagnosis must be made on the basis of positive findings, and not alone by excluding organic entities.

3. Psychogenic musculoskeletal symptoms were found in 11.1 per cent. of the patients hospitalized in the Orthopaedic Section. Among patients in the Orthopaedic Out-Patient Department, the incidence of psychological disorders was over 25 per cent. Approximately 1,000 patients with psychogenic musculoskeletal symptoms were studied.

4. Based upon the relationship to organic symptoms, three types of psychological problems were observed: (1) those occurring without known relationship to an organic lesion; (2) those secondary to and accompanying an organic lesion; and (3) those perpetuating symptoms of a healed organic lesion. Based upon psychiatric symptoms, the types seen were: (1) conversion reactions, (2) anxiety states, and (3) psychogenic elaboration of organic symptoms.

5. An abbreviated psychological history was obtained from all patients in whom the source of symptoms was obscure and the objective findings were bizarre.

6. Musculoskeletal pains of uncertain origin should be analyzed in terms of their exact character. Neurotic pains frequently include a sense of pressure, tension, or numbness. Bizarre radiating pains, particularly those radiating from a distal point proximally, are often psychogenic. Psychogenic and organic musculoskeletal symptoms are compared.

7. There may be several objective findings to identify a neurosis, or there may be none. The findings most often encountered include circumferential hypalgesia, hysterical paralysis, coarse intention tremors, and anxiety symptoms.

8. In 100 consecutive cases in which conversion reactions included circumferential hypalgesia, the patterns of hypalgesia are presented. Ten of the 100 patients had hysterical paralysis.

9. Sites of neurotic musculoskeletal symptoms are listed, together with some of the factors determining these sites.

10. The scope and use of superficial psychotherapy are discussed.

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PATHOMECHANICS OF THE HIP AFTER THE SHELF OPERATION

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It has been observed at this Clinic that many patients with dislocation or subluxation of the hip, who have been treated by the shelf operation, continue to limp, even if the shelf is strong and well built. This observation has been made previously by several authors, including Ober and Therkelsen, but it has frequently been overlooked.

The present study is based upon sixty-eight patients, eleven males and fifty-seven females, with dislocation of the hip. Fifty-nine of the dislocations were unilateral and nine were bilateral, making a total of seventy-seven dislocated hips on which the shelf operation was used in the Orthopaedic Department of the State University of Iowa. Thirty-seven dislocations were of the right hip and forty were of the left. There were sixty-one congenital dislocations; seven of these were of prenatal origin (Table I, Type A) and fifty-four were postnatal (Table I, Types B and C). Nine were congenital subluxations. Three were subluxations of paralytic origin, and one was a dislocation due to spastic paralysis. Three dislocations followed a suppurative arthritis.

The average follow-up period was seven years, with a minimum of four years and a maximum of twenty years. The ages of the patients at the time of operation varied from two and one-half years to thirty-six years.

Of the seventy-seven dislocated hips, fifty-two were dislocated upward—the so-called anterior dislocation. Thirteen were posterior dislocations, and twelve were subluxations. The small number of posterior dislocations in this series is due to the policy of the Clinic to use a subtrochanteric osteotomy in the treatment of most cases of irreducible posterior dislocation.

In forty-two hips the shelf was built over the femoral head, which had been placed in the primary acetabulum. In twenty-three cases the shelf was built with the femoral head in a secondary acetabulum. In twelve hips, most of which were dislocated posteriorly, the femoral head was completely dislocated and there was no secondary acetabulum.

In twenty-seven patients with redislocation or subluxation of the hip, the shelf operation was performed from one month to sixteen years after closed reduction. In fifty hips it was performed as a primary operation, with or without concomitant closed reduction.

In five patients the greater trochanter was detached, together with its muscle insertions, at the time of the shelf operation and was transposed from one to three centimeters down over the lateral aspect of the femur. In four of these patients the femoral head was reduced into the primary acetabulum at the beginning of the operation. In the other patient the femoral head was left in the secondary acetabulum.

RESULTS

Severin's standards were used to evaluate the anatomical results of the shelf operation. The standards for the functional results are the same as those previously used by the author.[4]

The *anatomical* results of treatment are indicated as follows: Group I, well-developed hip joints; Group II, moderate deformity of the femoral head, neck, or acetabulum in an otherwise well-developed joint; Group III, dysplasia, not subluxation; Group IV, subluxation; Group V, femoral head in a secondary acetabulum in the upper part of the primary acetabulum; Group VI, redislocation. The *functional* results of treatment are

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TABLE I

ANATOMICAL AND FUNCTIONAL RESULTS AFTER SHELF OPERATION FOR DISLOCATION OF THE HIP

Type of Dislocation	Anatomical Results	Functional Results — Shelving with Femoral Head in Primary Acetabulum					
		Group 1 No Symptoms	Group 2 Slight Pain	Group 3 Limp	Group 4 Limp and Limitation of Motion	Group 5 Limp and Pain	Group 6 Limp, Limitation of Motion, and Pain
Type A Prenatal dislocation (7 hips) 2½ to 5 years	I. Well-developed hip joint II. Moderate deformity of hip III. Dysplasia, not subluxation IV. Subluxation V. Head in secondary acetabulum VI. Redislocation				1		
Type B Postnatal dislocation (23 hips) Patients under 6 years	I. Well-developed hip joint II. Moderate deformity of hip III. Dysplasia, not subluxation IV. Subluxation V. Head in secondary acetabulum VI. Redislocation	1 2 1	1	1 1 1 3	1 2	2	2
Type C Postnatal dislocation (31 hips) Patients over 6 years	I. Well-developed hip joint II. Moderate deformity of hip III. Dysplasia, not subluxation IV. Subluxation V. Head in secondary acetabulum VI. Redislocation	1		2 1	3 1		1
Type D Subluxation (9 hips) All patients over 6 years	I. Well-developed hip joint II. Moderate deformity of hip III. Dysplasia, not subluxation IV. Subluxation V. Head in secondary acetabulum VI. Redislocation		2	2	1 2		1 1
Type E Paralytic subluxation (3 hips) Over 10 years	III. Dysplasia, not subluxation V. Head in secondary acetabulum			1 1	1		
Type F Spastic paralysis (1 hip) 11 years	IV. Subluxation				1		
Type G Following suppurative arthritis (3 hips) 3 to 8 years	IV. Subluxation V. Head in secondary acetabulum						
Totals: 77 hips		5	3	13	13	2	5
		41 hips *					

* In one hip of this group fusion resulted.

TABLE I (*continued*)

Functional Results												
Shelving with Femoral Head in Secondary Acetabulum						Shelving with Femoral Head in No Acetabulum						
Group 1 No Symptoms	Group 2 Slight Pain	Group 3 Limp	Group 4 Limp and Limitation of Motion	Group 5 Limp and Pain	Group 6 Limp, Limitation of Motion, and Pain	Group 1 No Symptoms	Group 2 Slight Pain	Group 3 Limp	Group 4 Limp and Limitation of Motion	Group 5 Limp and Pain	Group 6 Limp, Limitation of Motion, and Pain	Total Hips
												1
			3					1	1			5
												1
												3
		1						1				5
			1		1			1				4
												10
												1
												6
		1										1
		5	2	1	3				2		2	17
			1		2				1			4
												1
												3
												5
												1
												2
												1
												1
			1						1	1		2
		7	8	1	6			3	5	1	2	74
		22 hips **						11 hips ***				

** One patient of this group died a few hours after a shelf operation.
*** Postoperative infection, in one hip of this group, resulted in fusion.

given the following designations: Group 1, no symptoms; Group 2, slight pain in the hip on excessive walking; Group 3, limp, free motion, and no pain; Group 4, limp and limitation of motion, but no pain; Group 5, limp and pain; Group 6, limp, limitation of motion, and pain.

Telescoping: Before the shelf operation was performed, the telescoping sign was not present in thirteen hips, but in the remaining sixty-four hips this sign was observed. In fifty-one of the latter group the telescoping disappeared completely after the shelf operation; in eleven there was marked improvement; and in only one case of posterior dislocation, in which the shelf became absorbed, did the telescoping persist.

Trendelenburg Sign: In four hips the Trendelenburg sign was negative before the shelf operation was performed, and continued to be negative thereafter. The Trendelenburg sign was positive in the remaining seventy-three hips. In eight of these the Trendelenburg became negative from two to six months after the shelf operation and remained negative. In three patients there was marked improvement. In sixty-one hips the Trendelenburg sign continued to be positive.

Pain: Fifty-one hips were free of pain before the shelf operation and remained pain-free after the operation. In seven cases there was pain in the hip on admission, which disappeared after the operation. Four patients complained of pain and obtained no relief after the shelf operation. Fourteen hips were pain-free before the operation and became painful after it. Of this last group, eight patients were over ten years of age, and the shelf operation was performed after forceful open reduction, following the preoperative application of traction for a few weeks. In two of these patients the acetabular cavity was reamed and deepened at the time of the operation, resulting in great stiffness of the hip. The other six patients were under ten years of age, but all had posterior dislocations.

In Table I are shown the anatomical and functional results in the different types of dislocation, arranged according to the age of the patient and the position of the femoral head at the time of the shelf operation. Type A includes the dislocations which occurred before birth. Type B includes the patients under six years of age who were born with a dysplastic hip which showed the signs of predislocation. Complete dislocation took place during the first months of life. Type C includes postnatal dislocations in patients who were over six years of age at the time of the shelf operation. In Type D, or subluxation, the femoral head was situated in the upper portion of a deformed acetabular cavity, but was not completely dislocated. The patients in Type E had paralysis of the gluteal muscles, and subluxation of the hips occurred because of lack of muscle support. The patient in Type F had spastic paralysis with marked spasticity of the adductors; weakness of the gluteal muscles resulted in a dislocation of the hip. The patients in Type G had suppurative arthritis with pathological dislocation of the hip. The final functional results in the seventy-seven hips, as compared with the initial symptoms, are shown in Table II.

Of the thirteen hips dislocated posteriorly, it was possible in three instances to perform an open reduction, together with the shelf operation. Two of them resulted in hips of anatomical Group III,—one with no symptoms and the other with a slight limp. The other hip resulted in Group 4, with limp and limitation of motion. In the remaining ten cases the shelf operation was performed with the femoral head dislocated, either in a secondary acetabulum or in no acetabulum at all. In these cases the functional results were poor, except for two cases in which the dislocated femoral head was transposed anteriorly at the time of the shelf operation, resulting in slight limp but no pain.

In two hips the operation resulted in fusion. In one patient with prenatal dislocation, two and one-half years old, postoperative infection occurred. The other patient, fifteen years old, had a high anterior dislocation; treatment was by open reduction and the shelf operation.

One eight-year-old patient with a postnatal dislocation died of surgical shock a few hours after the shelf operation.

TABLE II

FINAL FUNCTIONAL RESULTS OF SHELF OPERATION IN PATIENTS WITH DIFFERENT INITIAL SYMPTOMS

Symptoms Present Before Shelf Operation	Final Functional Results							
	Group 1 No Symptoms	Group 2 Slight Pain	Group 3 Limp	Group 4 Limp and Limitation of Motion	Group 5 Limp and Pain	Group 6 Limp, Limitation of Motion, and Pain	Fusion	Patient Deceased
Group 2 Slight pain in hip on excessive walking (3 hips)		1				2		
Group 3 Limp, free motion, and no pain (66 hips)	5	1	20	26	3	8	2	1
Group 4 Limp and limitation of motion, but no pain (3 hips)						3		
Group 5 Limp and pain (5 hips)		1	3		1			
Totals: 77 hips	5	3	23	26	4	13	2	1

Four hips redislocated a few months after the shelf operation; three were posterior dislocations and the other was an anterior dislocation. In three of these cases the shelf became completely absorbed, and in the other case the femoral head was markedly anteverted and redislocated anteriorly to the shelf.

COMMENT

The results given here and in Tables I and II indicate that all the patients treated by the shelf operation, performed with the femoral head situated in a secondary acetabulum or in no acetabulum, continued to limp.

Of the forty-two shelf operations performed with the femoral head in the primary acetabulum, a normal hip joint developed in only one, and in five the final result was a moderate deformity of the hip. One hip in a fifteen-year-old patient became fused after forceful reduction and a shelf operation. In the remaining thirty-five hips the femoral head became displaced outwardly after the shelf operation, resulting in dysplastic hips (Group III) or subluxations. Frequently, however, the femoral head finally became stabilized in a secondary acetabulum situated somewhat above the primary acetabulum and away from the line of gravity. From the functional point of view, in only eight patients did the limp disappear,—five hips became symptomless and three were only slightly painful on strenuous walking. The remaining thirty-four patients continued to limp, some of them developed limitation of motion, and a few had pain.

After the shelf operation, then, the femoral head became stabilized, either in the primary acetabulum or in a secondary acetabulum; the telescoping disappeared; but most of the patients continued to limp. If the strength of the hip muscles has been preserved by careful surgery, the poor functional results of the shelf operation, performed with the head placed in the primary acetabulum, can only be explained on the basis that the hip with a surgically created shelf is mechanically defective. Normally, the hip joint is considerably separated from the line of gravity, and consequently the gravital forces determine a rotatory effect upon its center of motion. The rotatory moments developed by the gravital forces upon any joint are equal to the product of body weight times the per-

pendicular distance from the center of motion of the joint to the line of gravity.[7] If, after a shelf has been built, the center of motion of the hip becomes abnormally separated from the line of gravity, the rotatory moments acting upon this hip will be greatly increased.

In all of the anteroposterior roentgenograms of these patients, measurements were made of the perpendicular distance between the center of the femoral head and a line drawn through the longitudinal axis of the sacrum, which represents approximately the line of gravity. This distance is the so-called Y coordinate for the hip joint, and in normal hips it varied from 5.5 centimeters in a child, two and one-half years old, to 9 centimeters in a woman of twenty-eight. The Y coordinate is slightly larger in females than in males. The normal value of the Y coordinate of the center of the hip joint, according to the calculations of Braune and Fischer, is 8.5 centimeters.[7] In the patients with unilateral dislocation in whom the shelf operation produced good anatomical and functional results, the Y coordinate for the hip with a surgically created shelf measured the same as, or less than 1.2 centimeters more than, the Y coordinate for the normal hip. On the other hand, in the patients with unilateral dislocation who had poor functional results from the shelf operation, the Y coordinate of the shelved hip was from 1 centimeter to as much as 5 centimeters larger than the Y coordinate of the normal hip, and the greater this difference, the more pronounced was the limp (Figs. 1 and 2).

In the patients in whom the limp disappeared after the shelf operation, it was noted that the femoral head was centrally placed in the primary acetabulum at the time the shelf was constructed, and remained there during and after the period of immobilization.[5] The shelf in such a hip usually became smaller after a period of walking, and in some

FIG. 1

J. R., No. 38–15836. Girl with congenital dislocation of right hip. Shelf operation done when patient was seven years of age. Roentgenograms taken at eleven years of age show that the Y coordinate of the right hip measures 9.5 centimeters, whereas the Y coordinate of the left hip measures 6.5 centimeters. Consequently, the Trendelenburg sign is positive on the right and negative on the left. Notice that the entire right iliac bone is deformed.

FIG. 2

H. M., No. 38-15654. Girl with bilateral dislocation of hip, treated by bilateral closed reduction at three and a half years of age. Shelf operation performed on left hip at five years of age, because of redislocation. Roentgenograms taken at seven years show that the Y coordinate measures 7.3 centimeters for the right hip and 8.5 centimeters for the left hip. Trendelenburg sign is negative on the right, positive on the left.

cases it seemed to disappear completely (Fig. 3-D). The Trendelenburg sign became negative within from two to six months after the patient began to walk following the shelf operation.

In most cases, however, the shelf was built at the upper end of a sloping acetabular roof; and, when the patient started to walk, the femoral head came under the shelf, at a somewhat higher level than the normal hip and slightly more separated from the line of gravity. Thus the acetabular cavity, with its roof widened by the shelf, provides for the femoral head a fulcrum which is mechanically defective, because it is too far separated from the line of gravity.

The passive support offered by a well-built shelf is not enough to maintain the central position of the femoral head in the acetabular cavity. The active stabilizing action on the hip joint is provided by the hip muscles, mainly the gluteus medius. If this muscle has been weakened by surgery, followed by a period of immobilization in a cast, the femoral head will not remain well centralized in the acetabular cavity when the patient begins to walk, in spite of a well-built shelf. The capsule and ligaments of the hip joint must also become shorter to secure complete reduction of the femoral head.

The hip muscles are not strong enough to neutralize the rotatory effect produced by gravity upon a hip with the femoral head subluxated under the shelf, and consequently the Trendelenburg sign becomes positive. In the hips where this sign remained positive for more than six months, both functional and anatomical results became permanently poor. Due to the inability of the glutei to stabilize the new joint, the pelvis tilts toward the opposite side with every step and the femoral head slips somewhat upward but mainly

FIG. 3-A

FIG. 3-B

FIG. 3-C

FIG. 3-D

B. B., No. 38-15173. Girl with bilateral dislocation of hips, treated by closed reduction.

Fig. 3-A: Subluxation of left hip, one month after removal of cast (Apr. 24, 1936).

Fig. 3-B: Shelf operation performed on left; the femoral head is well centralized in the acetabular cavity.

Fig. 3-C: One and one-half years after operation.

Fig. 3-D: Eight years after shelf operation. The shelf has disappeared, but the result is good. The right hip is subluxated. Trendelenburg sign is negative on the left and slightly positive on the right.

outward, where the shelf is less resistant. The bone of the shelf reacts to the intermittent pressure of the femoral head by forming new bone, and frequently the shelf not only becomes thicker but also wider in order to house the displaced femoral head. The center of motion of the hip becomes more and more separated from the line of gravity; and, therefore, the limp will persist, even if the glutei become stronger (Fig. 4-C).

The best functional results are seen, not in the hips with a stouter shelf, but in those where the femoral head is close to the line of gravity. In patients with bilateral shelf operations, it is frequently seen that the Trendelenburg sign and the limp are more marked on the side where the femoral head is farther from the line of gravity, even if the shelf is well developed, than on the side where the femoral head is closer to the line of gravity, even though the shelf may be atrophic or fragmented (Fig. 5). The aim of treatment for hip dislocation, therefore, is not the construction of a big shelf, but the exact centralization of the femoral head in the acetabular cavity during and after the period of immobilization. For these reasons careful surgery is essential, avoiding damage to the muscles. When the cast has been removed after the shelf operation, a period of controlled functional treatment with the abduction bar is indicated, as used by the author in the after-treatment of closed reduction.[4]

To improve the action of the gluteus medius it has been suggested that the greater

FIG. 4-A

FIG. 4-B

FIG 4-C

FIG. 4-D

M. M., No. 38-15832. Girl with congenital dislocation of right hip, treated by closed reduction at the age of twenty-one months.

Fig. 4-A: Shows redislocation, three months after removal of cast.

Fig. 4-B: Four months after shelf operation. The femoral head is not well centered in the primary acetabulum.

Fig. 4-C: A year and nine months after the shelf operation (Apr. 10, 1940). The femoral head became displaced away from the line of gravity and the shelf reacted by becoming thicker and wider.

Fig. 4-D: Six and one-half years after shelf operation. The Y coordinate measures 9.5 centimeters for the right hip and 7 centimeters for the left hip. Trendelenburg sign is positive on the right.

trochanter, together with its muscle insertions, be transposed downward over the lateral aspect of the shaft of the femur. In five hips of the present series, this procedure was followed, in addition to the shelf operation. In four of these hips the femoral head was reduced into the primary acetabulum, and the functional result was poor in all (two of Group 4 and two of Group 6). The other hip was dislocated posteriorly and the shelf operation was performed with the femoral head in a secondary acetabulum; the functional result was bad (Group 6). In neither hip could benefit be attributed to the transposition of the greater trochanter. When bone shortening and bone lengthening are performed for equalization of the extremities, the muscles adapt themselves to the new situation and become structurally shortened or lengthened, corresponding to the approach or separation of the points of origin and insertion. Steindler has stated that: "The contracted muscle in adapting itself readily to the new mechanical arrangement becomes a new complete and rational mechanical unit". The transposition of the greater trochanter is thus worthless and unnecessary.

It is easy to understand why the limp persisted in all patients in whom the shelf was

built over the femoral head in a secondary acetabulum or in no acetabulum. In these patients the center of motion of the dislocated hip joint was already beyond the normal distance from the line of gravity. This distance is certainly not shortened by the creation of a shelf.[1] The force of the gluteus medius is not strong enough to oppose the great rotatory effect acting over this displaced center of motion; and, consequently, the Trendelenburg sign will remain positive and the patient will continue to limp.

If the hip is dislocated posteriorly, we have to consider not only the rotatory effect upon the hip joint in the frontal plane, but also in the sagittal plane. The line of gravity in the sagittal plane normally passes through or slightly behind the hip joint. If the center of motion of the hip is displaced backward, the pelvis will tilt not only to the opposite side, but also forward. Under these conditions a shelf will be a mechanical failure, unless the femoral head can be reduced into the primary acetabulum, or at least be transposed anteriorly, thus neutralizing the forward tilt of the pelvis.

FIG. 5

J. R., No. 38–10866. Roentgenogram of an eight-year-old girl with congenital dislocation of the hips, who had been treated by bilateral shelf operation at three years of age. The Y coordinate of the right hip is 7 centimeters; that of the left hip is 8.3 centimeters. The Trendelenburg sign is negative on the right, although the shelf is fragmented, because the femoral head is well centralized in the acetabular cavity and is close to the line of gravity. On the left the Trendelenburg sign is positive, in spite of a stout shelf, because the femoral head is away from the line of gravity.

INDICATIONS FOR THE SHELF OPERATION

In young children with congenital dislocation of the hip treated by closed reduction, prolonged and controlled functional after-treatment by means of the abduction bar has shown that a shelf is not necessary to maintain reduction of the femoral head. The development of the hip muscles before the patient is allowed to walk, and the prolonged positioning of the limb in abduction and inward rotation [4] have been sufficient to maintain the femoral head well centralized in the acetabular cavity. When this has been accomplished, the acetabular roof develops well.

In children over four years of age, if the closed reduction has failed and an open reduction has been carried out successfully, the construction of a shelf may be indicated in case the acetabulum is very shallow. One must not rely too much on the shelf. To secure a good result, it is essential to place the lower extremity in a position of abduction and inward rotation for three months in a cast, followed by prolonged and well-directed functional after-treatment.

Symptoms are absent or very mild in patients with congenital subluxation until adult life; then pain, more or less severe on walking, and a mild limp usually develop. The pain is usually well controlled by a shelf operation. By giving a bony support to the femoral head, the strain on the capsule and ligaments of the hip joint is relieved; and, consequently, the pain disappears, although the limp may persist. A shelf operation is thus indicated in patients with congenital subluxations after the development of pain on walking and a slight limp. The operation is also indicated in a patient with congenital dislocation of a hip, reduced in childhood, which becomes subluxated after puberty.

When the femoral head cannot be reduced into the primary acetabulum, the hip will always be mechanically defective, in spite of a shelf operation. Although the telescoping is abolished and the pain on walking diminishes for a certain period of time, pain and

limitation of motion frequently appear a few years after the shelf operation has been performed. Osteo-arthritis of the hip usually accounts for these symptoms. It is the experience of this Clinic that, in patients with irreducible dislocations, a well-performed Schanz osteotomy, as outlined by Milch, gives good functional results, because the direction of the weight-bearing stresses is changed and approaches the line of gravity, thus improving the stability of the pelvis. In adult patients with complete, irreducible dislocation of the hip—unilateral or bilateral—a Schanz osteotomy is mechanically a better operation than a shelf operation.

It must be noted that, if a Schanz osteotomy is performed in a child, the angle of osteotomy will slowly diminish and the femur may even become completely straight as the patient grows. Young patients with irreducible dislocated hips thus present a difficult problem. The limp is their only symptom, and this will not disappear after a shelf operation. If a Schanz osteotomy is performed, it will probably have to be repeated when the patient reaches adult age. Even without treatment, in the patients with irreducible anterior dislocations a secondary acetabulum develops, and usually the femoral head does not dislocate farther upward. We believe that these patients should be observed periodically until puberty and, if pain occurs at that time, a Schanz osteotomy should be performed. Young patients with irreducible posterior dislocations are better treated by a Schanz osteotomy, even before puberty, if the femoral head tends to become more and more displaced upward and backward under the iliac wing. If the angle of the osteotomy diminishes, a second operation may be performed after puberty. The anterior transposition of the femoral head is a laborious and traumatizing procedure, which cannot always be accomplished.

Observation of this series indicates that the results obtained by shelf operations after forceful reduction of the hip, with or without preoperative traction of the limb, are very poor.[8] Reaming or deepening of the acetabular cavity usually results in stiffness of the hip joint.

SUMMARY

Dislocated or subluxated hips became more stable after a shelf operation, and the telescoping disappeared. However, the Trendelenburg sign remained positive, and consequently the limp persisted in all the patients with hip dislocation, treated by the shelf operation with the femoral head in a secondary acetabulum or in no acetabulum. When the shelf was built over the femoral head, after it had been placed in the primary acetabulum, the Trendelenburg sign became negative in only 18 per cent. of the patients. This sign remained positive in many patients, because, after the shelf operation, the femoral head usually became displaced under the shelf away from the line of gravity of the body. When the patient started to walk, the hip muscles were impotent to neutralize the increased rotatory effect produced by gravity upon this displaced center of motion. The Trendelenburg sign became negative only when the femoral head remained well centralized in the primary acetabulum. In these patients the shelf became smaller or even disappeared. On the other hand, in the patients whose Trendelenburg sign continued to be positive, the shelf became thicker and wider, due to the intermittent pressure of the displaced femoral head against the shelf.

From these observations, it was concluded that the aim of treatment for dislocation of the hip is not the construction of a big shelf, but the exact and permanent centralization of the femoral head in the acetabular cavity. The shelf alone is unable to accomplish this. The hip muscles must become strong and the capsule and ligaments of the hip joint must shrink to make secure the complete reduction of the femoral head. This may be accomplished in young patients by prolonged and well-directed functional after-treatment following reduction, with or without a concomitant shelf operation.

In the author's experience, the two main indications for the shelf operation are as follows: (1) In children over four years of age with congenital dislocation, reduced by

the open method, a shelf may be created if the acetabulum is shallow; and (2) in patients with congenital or paralytic subluxation, or with subluxation of an old reduced congenital dislocation, the shelf operation is indicated when pain of static origin and a limp appear, usually after puberty. When reduction of the femoral head cannot be maintained in the primary acetabulum, the shelved hip will always be mechanically defective; a Schanz osteotomy is indicated in these cases.

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EARLY SECONDARY CLOSURE FOLLOWING SAUCERIZATION FOR CHRONIC INFECTION OF BONE

A Preliminary Report

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The widely accepted Orr-Trueta, or closed-plaster, technique has been until recently the method of choice in treating chronic exogenous osteomyelitis. There are, however, several undesirable factors associated with this method of treatment,—namely: (1) the prolonged period of healing; (2) the stench of the soiled cast and consequent lowering of the patient's morale; (3) the presence of avascular scar tissue in the healed wound; and (4) the loss of essential body fluids.

The first and third points are of the most significance in the treatment of war casualties. Bed space in Army general hospitals has been limited, and consequently any form of treatment which will decrease a patient's period of hospitalization is desirable. In many cases, there has been extensive loss of bone, which will necessitate bone-grafting at a later date. To ensure the optimum opportunity for the eventual success of such grafting procedures, one must have a soft-tissue bed which is as vascular and as free from scar tissue as possible. This is not afforded by the closed-plaster method.

Stimulated by the success of Kelly and Burgess of the Fifth Service Command in covering depressed, granulating, post-saucerization wounds with split-thickness skin grafts, the author began to experiment with early secondary closure. When a granulating, saucerized depression is covered with a split-thickness skin graft, a lined depression results. This depression should be obliterated and the edges of the normal skin should be approximated, particularly if further bone surgery is required. It then seemed logical, in regions where it was possible, to circumvent this intermediate step and secondarily to close the skin edges of the saucerized wound. If this procedure should be successful, the period of hospitalization would be diminished by months and perhaps by years. It was assumed that these "dirty" wounds could be closed as satisfactorily as they could be grafted.

This method of treatment is contrary to many accepted principles of good surgery. A septic wound is completely closed, without drainage. The assistance derived from the use of penicillin and the sulfonamides has been great, but it is almost impossible to evaluate accurately the relative importance of these agents and of the surgical procedure. One may hazard a guess, however, that the method would have failed had penicillin and the sulfonamides not been available.

The general condition of a patient with a chronic infection of the bone should be evaluated upon admission to the hospital. Before a surgical procedure is carried out, the patient's hemoglobin, total proteins, and albumin-globulin ratio must be approximately normal. Beginning forty-eight hours before the operation, the patient should be given 25,000 units of penicillin systemically every three hours, day and night; and one and one-half grams of sulfadiazine by mouth every six hours, day and night. On the third day he is taken to the operating room. A pneumatic tourniquet is applied, if possible, to the extremity. Material for cultures is taken from the sinus, which is then injected with equal parts of methylene blue and hydrogen peroxide, in order that the extent of the infected cavity may be delineated. The entire dyed area is widely and meticulously saucerized; great care should be exerted to remove all scar tissue and any overhanging ledges of bone or of soft tissue. The wound is "frosted" with sulfanilamide crystals. One or more lengths of soft rubber tubing, with a lumen of one-eighth of an inch, are inserted into the depth of the wound. The tubing is transfixed to the skin by a catgut

suture. The wound is then packed *firmly*, but not tightly, with fine-meshed plain gauze packing, which has a thread count of sixty to the inch. Muslin which has been impregnated with petrolatum is used to cover the packed wound, and the tubing emerges through openings in the muslin. The extremity is encased in plaster, and the tubes are brought through the plaster to the surface. The antibiotics are continued as before operation. Penicillin (one cubic centimeter containing 750 units), in quantities of from five to fifteen cubic centimeters, is injected into the tubes twice daily.

On the eighth day after saucerization, a window is cut in the cast or the cast is bivalved. The packing and tubing are removed. At this time the decision is made as to whether the wound will be treated by skin-grafting or by secondary closure.

The author has found that saucerized wounds on the arm, forearm, thigh, buttocks, or shoulders lend themselves to satisfactory secondary closure, whereas those on the leg or foot, or in the region of the elbow or knee, can be treated more satisfactorily by skin-grafting. The primary prerequisite of a successful secondary closure is the availability of adequate soft tissue which can be mobilized sufficiently to obliterate the excavation. The procedure chosen should be carried out, ideally, on the ninth or tenth day after saucerization.

Packing which has been soaked in half-strength Dakin's solution is inserted in the wound after the first dressing. The packing is changed daily, and is finally removed in the operating room.

For secondary closure, the skin surrounding the wound is prepared in the routine manner. No chemicals are allowed to enter the wound. The skin edges and the granulating walls of the cavity are resected; bleeding is controlled with hot saline packs. The wound surfaces are "frosted" with sulfanilamide crystals. An effort is made to obliterate all dead space, but this is frequently impossible, as the soft tissues cannot be mobilized adequately to fill the dead space in the underlying bone. Layers of muscle and of fascia are closed with interrupted sutures of fine chromic catgut. The skin is widely undercut to allow closure without tension on the edges. Great care must be taken to obliterate any subcutaneous dead space which may be present. The persistence of such a space is the commonest cause of incomplete healing and of continued serosanguineous discharge. The skin may be closed with absorbable or non-absorbable sutures, at the discretion of the operator.

After secondary closure, the antibiotics are resumed, in doses similar to those given before and after saucerization. This medication should be continued for at least one week after operation, or longer if local conditions warrant.

The first postoperative dressing is done on the eighth day, and the degree of healing can be evaluated at this time. To be considered "completely healed", the wound must be dry, and must be without drainage, subcutaneous dead space, or skin ulceration. For the purposes of this report, a wound was not considered "completely healed" unless it had remained so for thirty days after the secondary closure.

The results in the first fifty cases of secondary closure of post-saucerization wounds, performed at Nichols General Hospital, are reported. It will be noted that in a number of cases the period between saucerization and secondary closure was prolonged. The procedure described in this paper was not instituted until early in March 1945. At that time, many wounds which had been saucerized several months before and had been treated by the closed-plaster method were still unhealed. These wounds were closed secondarily.

Of the fifty cases, thirty-five, or 70 per cent., healed primarily; fifteen, or 30 per cent., were classified as incompletely healed. Eight of the fifteen were healed one month after secondary closure. Therefore, one month after secondary closure, forty-three, or 86 per cent. of all the closures, were completely healed. Not one of the fifty cases could be classified as a complete failure. The poorest case was estimated to have 35 per cent.

TABLE I

RESULTS OBTAINED FROM SECONDARY CLOSURE FOLLOWING SAUCERIZATION

Location	Total Number of Cases	Healed (*Number*)	Healed (*Per cent.*)	Incompletely Healed (*Number*)	Incompletely Healed (*Per cent.*)
Shoulder	2	2	100	0	0
Upper arm	10	10	100	0	0
Forearm	9	7	77	2	23
Thigh	16	12	75	4	25
Leg	1	0	0	1	100
Foot and ankle	1	0	0	1	100
Joint areas	7	1	14	6	86
Pelvis	4	3	75	1	25
Totals	50	35	70	15	30

healing. A number of cases which had been classified as incompletely healed were secondarily closed a second time, and complete healing occurred eventually.

There is considerable variation in the time which elapsed between saucerization and secondary closure. The earliest closure which was attempted after saucerization was done in seven days, the latest in 126 days. Both resulted in complete healing. The average number of days which elapsed between saucerization and secondary closure was 27.6. In nineteen, or 38 per cent., of the fifty cases, secondary closure was performed ten days or less after saucerization; in thirty-one, or 62 per cent., closure was delayed for more than ten days. Of the nineteen wounds which were closed in ten days or less, nine, or 48 per cent., were healed completely at the time of the first dressing; ten, or 52 per cent., were considered unhealed. Twenty-six, or 84 per cent., of the wounds closed in something over ten days after saucerization healed primarily; five, or 16 per cent., were classified as unhealed. When we consider that, in the cases of very early secondary closure, we are attempting closure of grossly infected wounds, while in the cases of late secondary closure we are practising excision of chronic granulating wounds, the comparison is not too striking. The objectives of early closure are to produce healing with a minimum of fibrosis and to decrease appreciably the period of hospitalization. A delay of 126 days between saucerization and secondary closure certainly fails to accomplish either objective. The risk of failure in early secondary closure is obviously greater than that encountered in cases where closure has been postponed unduly. However, the risk is compensated for by the relatively high percentage of satisfactory results and the great saving in hospital days.

The anatomical distribution of the cases and the percentages of healing and incomplete healing are shown in Table I. The percentage of complete healing in regions proximal to and involving the joints was low, but of the seven cases in which secondary closure was attempted in these areas, all but one are now completely healed. Further surgery will be required in this case.

No extensive bacteriological studies were instituted. Material for culture was taken from the existing sinus or sinuses at the time of saucerization. Thirty-five per cent. of the wounds contained hemolytic *Staphylococcus aureus*. Most of the wounds had a superimposed *Bacillus proteus* infection. Culture material was not taken from the wounds at the time of secondary closure.

INTERTROCHANTERIC FRACTURES AND FRACTURES OF THE NECK OF THE FEMUR

A Guide and a Method of Procedure for Accurate Placement of a Nail

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The need for a simple, accurate, and practical guide for nailing hips is obvious. A review of the literature reveals many different devices for this purpose, with most of which the orthopaedic surgeon is familiar.

The guide described here removes the element of luck and affords mechanical efficiency in accurately nailing all types of fractures of the femoral neck and intertrochanteric fractures. When properly applied to the femur, it will permit the accurate introduction of the wire and nail at the desired angle in both the anteroposterior and lateral planes.

The guide consists of a block of stainless steel (18–8), diagonally divided and held in one piece with two dowel pins and one set screw (Figs. 1, 2, and 3). This division permits proper cleaning after use. The block is roughly two inches wide, three-quarters of an inch thick, and two and one-half inches long. There are three flat surfaces, one rounded surface, and one surface tunneled in V shape, which contains fixation prick pins to be applied to the lateral surface of the femur. This V-shaped surface is notched for the purpose of getting accurate alignment on the lateral roentgenograms. At the center of one notch there is a hardened drill bushing for pin transmission. On the opposite side of the V-shaped surface there is a drill hole, three-sixteenths of an inch in diameter and seven-eighths of an inch deep, which receives the vertical rod, adjustment screw, and clamp assembly which hold the block firmly against the lateral femoral surface. The rounded surface has twelve drill holes, three-thirty-seconds of an inch in diameter, placed at angles of 20 degrees, 30 degrees, 45 degrees, and 55 degrees. They all converge to a common center at the apex and pass through the drill bushing (Fig. 2, *b*). The holes are set three in line vertically and four in line horizontally, and through them pass four V-shaped notches, which afford contrast on the roentgenogram and permit proper alignment. The block may be used for the right or left side simply by turning it over. It is held in position against the femur by a clamp assembly (Figs. 4 and 5), which consists of the following parts: two arms, one yoke, and two adjustment screws,—one vertical and one horizontal.

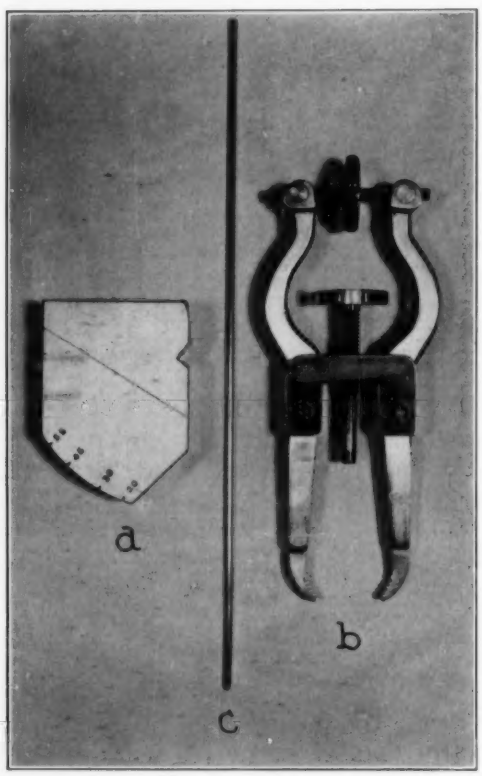

FIG. 1

a: Shows the block, sighting V at drill bushing, diagonal line where block can be separated, and four small V's at angles of 20, 30, 45, and 55 degrees.

b: Shows the clamp assembly.

c: Shows a Steinmann pin.

The application of this guide is rapid, safe, and simple. The steps in the procedure are as follows:

1. With the patient under anaesthesia, the fracture is reduced and the limb is fixed in full internal rotation to the foot-piece of the orthopaedic operating table. The rotation removes the normal anterior inclination of the femoral neck.

2. The reduction is checked by means of two portable roentgenographic machines, placed for anteroposterior and lateral views.

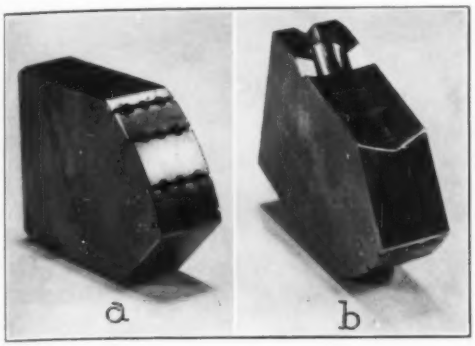

FIG. 2

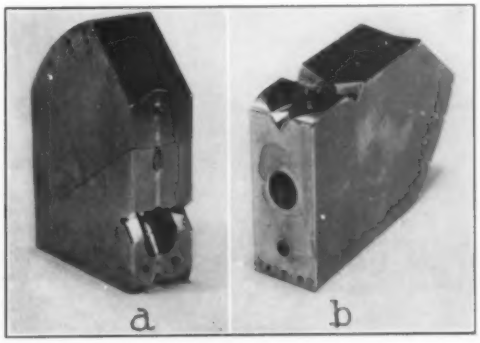

FIG. 3

Fig. 2, *a*: Shows the curved surface of the block, the small sighting V's, twelve drill holes, and the three-sixteenth-inch drill hole for the vertical rod of the clamp. *b*: Shows the prick pins, center drill bushing, the lateral and anteroposterior sighting V's, and the V-shaped surface.

Fig. 3, *a*: Shows a dowel pin, sighting V, and prick pins. *b*: Shows two sighting V's, three prick pins, the drill bushing, and set screw to hold block in one piece.

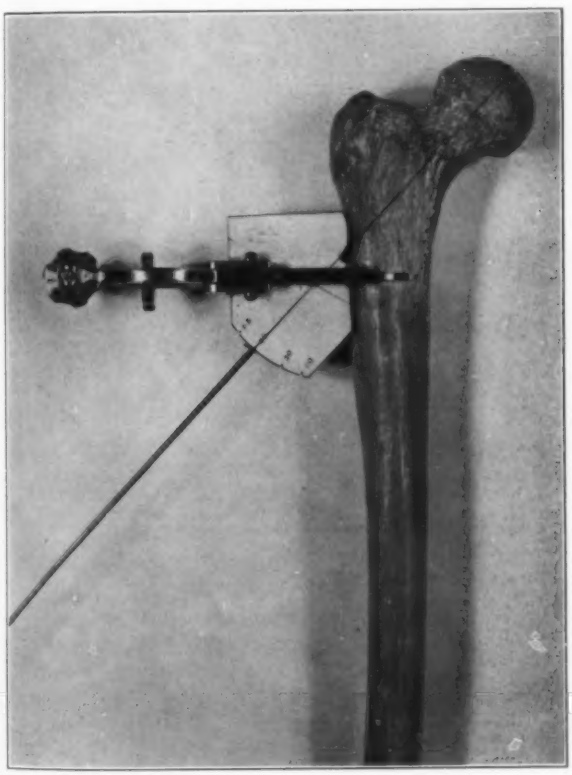

FIG. 4

Shows the application of the guide to the femur in the anteroposterior plane. Guide wire is in the center 45-degree hole, with a thread extended over the femoral head and neck.

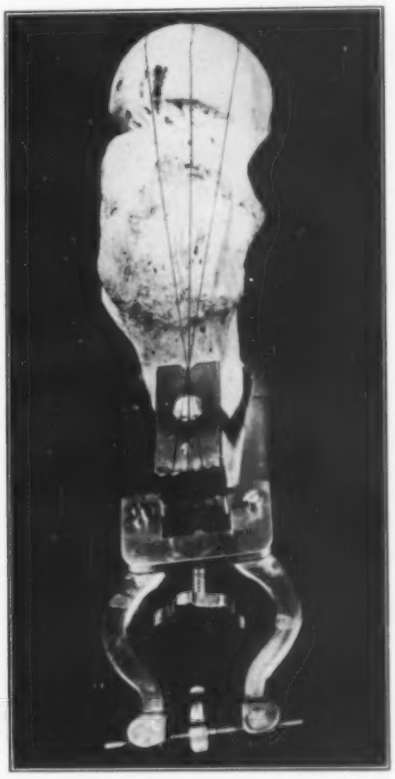

FIG. 5

Shows guide applied to femur in superior-inferior plane, with three threads to show angles of center, upper, and lower holes in the block.

3. If the reduction is found to be satisfactory (Figs. 6-A and 6-B), the operative site is prepared.

4. An incision, three and one-half to four inches long, is made along the lateral border of the femur, extending distally from the greater trochanter. The femur is exposed.

5. The block is placed in the clamp assembly and the serrated clamps are applied to the upper shaft of the femur (Figs. 6-C and 6-D); the upper surface of the block should be within one-half inch of the lower margin of the greater trochanter. The guide block is screwed firmly against the outer cortex of the shaft of the femur; it should be about midway

FIG. 6-A

FIG. 6-B

Anteroposterior and lateral roentgenograms, showing fracture of the right femoral neck, after reduction.

FIG. 6-C

Anteroposterior view shows the guide and pin applied to the femoral shaft.

FIG. 6-D

Lateral view partially shows the guide applied to the femur.

between the anterior and posterior surfaces of the shaft and level to the naked eye on its flat upper surface,—that is, parallel to the flat anterior surface of the femoral shaft.

6. A nail guide pin is placed in the center hole of the 45-degree angle.

7. Anteroposterior and lateral films are taken so as to include in the film the guide with the pin.

FIG. 6-E

FIG. 6-F

Anteroposterior and lateral roentgenograms, showing the guide pin extending beyond the line of fracture.

FIG. 6-G

Anteroposterior view of nail in position selected, at conclusion.

FIG. 6-H

Lateral view of nail, with minimum rotation of femoral head, at conclusion.

FIG. 6-J
Oblique view of fracture of the right femoral neck.

FIG. 6-I
Anteroposterior view of fracture of the right femoral neck.

8. A sight is taken along the pin and the grooved notches in the block on the anteroposterior and lateral films, and, with a straight edge on the film, a determination is made of the exact hole to be used to place the nail properly.

9. Using this hole, the guide pin is placed in a hand drill and inserted to the desired depth (Figs. 6-E and 6-F).

10. The block and clamp assembly are removed, but the pin is left in place.

11. With a 0.333-inch cannulated drill over the wire, a hole is cut in the cortex of the femur to receive the cannulated nail. With a special ruler, the nail length can be estimated or calculated from the known width of the block (two inches) accurately enough for all practical purposes. The distortion is usually about one to four.

12. The nail is placed on the introducer and driven into the femoral neck (Figs. 6-G and 6-H).

13. The foot fixation to the table is released, the fracture is impacted, and final anteroposterior and lateral films are made.

14. The guide pin is removed and the wound is closed in layers.

The following illustrative case is taken from a series of over twenty-five cases in which the author has used this procedure:

A. K., No. 8062, a married housewife, aged fifty-six, slipped on an icy doorstep and fell on her right hip one hour before admission to the Strong Memorial Hospital on December 1, 1945. She had instantaneous pain in the right hip, with numbness and weakness of the right leg and inability to walk.

On physical examination, the right leg was found to be shortened and in a position of external rotation. There was tenderness over the greater trochanter. Attempts at motion were painful. The general physical examination was otherwise not remarkable. Roentgenograms showed a fracture of the right femoral neck (Figs. 6-I and 6-J). The patient was a known diabetic, whose disease was regulated with insulin.

The patient was subjected to the procedure outlined, and the results are shown in Figures 6-A to 6-J, inclusive. The postoperative course has been uneventful to date.

CONCLUSIONS

It is not always essential to use a mechanical device for nailing intertrochanteric fractures and fractures of the neck of the femur, but with such a method the nail may be placed in the desired position with certainty.

This device eliminates the need for fluoroscopy, which is not universally available nor entirely without risk. The results are frequently too indistinct to be of much help in large or obese patients, and biplane observation is not possible.

This guide helps eliminate improper placing of the nail at the time of operation, and reduces the time required for nailing the hip. It also reduces the cost for film, because fewer exposures are required, and it saves time for the roentgenologist.

By introducing only one guide wire, operative trauma at the site of injury is minimal.

The guide remains in a fixed position after it has been applied.

NOTE: The author wishes to thank R. Plato Schwartz, M.D., for his valuable suggestions, and Dr. Rachel Rice for her assistance.

A SIMPLIFICATION OF BANKART'S CAPSULORRHAPHY FOR RECURRENT DISLOCATION OF THE SHOULDER

BY COMMANDER F. HAROLD DOWNING

Medical Corps, United States Naval Reserve

The anterior capsulorrhaphy of Bankart has proved to be a most satisfactory operative procedure for recurrent dislocation of the shoulder, according to the author's observations. Its chief disadvantage is the technical difficulty encountered in carrying out the procedure as described by Bankart,—namely, suturing the humeral portion of the shoulder capsule to the rim of the glenoid and securing satisfactory fixation of soft tissue to bone. By the use of a stainless-steel staple, made from sixteenth-inch Kirschner wire, a special instrument for the insertion of this staple, and a special retractor (Fig. 1), the technical difficulties of the operative procedure have been overcome. The coracoid process need not be removed and it is only necessary to section the inferior half of the tendinous insertion of the subscapularis for adequate exposure. The operative time is practically cut in half, and the associated operative trauma is similarly reduced. In fact, one patient was operated upon satisfactorily without either section of the subscapularis or opening of the joint capsule.

OPERATIVE TECHNIQUE

A five-inch incision is made, beginning just above the coracoid process and extending downward between the borders of the deltoid and the pectoralis major. The cephalic vein is located and is retracted laterally with the deltoid. By dissection of the muscle plane, the deltoid and the pectoralis major are separated and retracted. The coracoid process is located, and into it are inserted the short head of the biceps, the coracobrachialis, and the pectoralis minor. With the shoulder in external rotation, the cleavage plane between the lateral border of the short head of the biceps and the subscapularis is defined and dissected; the muscles attached to the coracoid process are retracted medially. The distal and inferior border of the subscapularis is separated by blunt dissection, and the gloved finger is passed along this border to the antero-inferior margin of the glenoid cavity; by blunt dissection with the finger, the muscular attachments of the subscapularis to the antero-inferior portion of the capsule are freed up to its tendinous insertion.

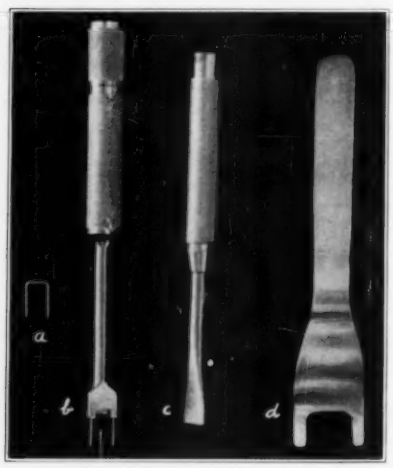

FIG. 1

The author's instruments for capsulorrhaphy. *a*: Staple. *b*: Staple holder, used for insertion and extraction. *c*: Staple set. *d*: Retractor.

Two No. 2 chromic sutures are then placed in the inferior half of the subscapularis tendon, and by retraction on these and by placing a large curved hemostat under the subscapularis, the tendinous insertion is defined and is slowly severed with a scalpel. This is a very important step in the procedure; unless the muscle fibers of the subscapularis are first dissected free from the capsule, as described, it is difficult to define the tendinous insertion and one may open into the joint capsule at a non-elective location. The only open tears the author has seen in the capsule have been those caused by the operator. When the inferior half of the subscapularis tendon has been divided, the special retractor is placed so that its bifurcated end rests on the neck of the glenoid cavity, and thus about one-half inch below the glenoid rim. This holds the subscapularis and the muscles attached to the coracoid process

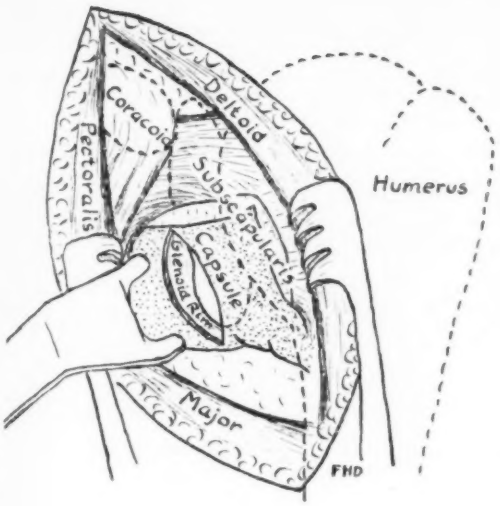

FIG. 2

Exposure of the antero-inferior glenoid margin and the capsular incision.

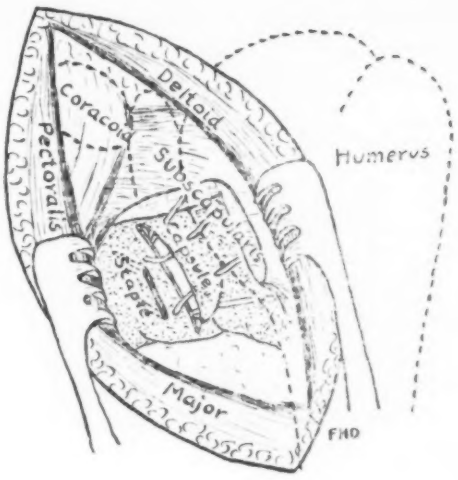

FIG. 3

Position of staple and technique of capsular repair.

behind the retractor, and exposes the antero-inferior portion of the glenoid rim, which is the location to be repaired.

The capsule is now entered by a one-inch incision, parallel to and just lateral to the glenoid rim (Fig. 2). The defect in the fibrocartilaginous attachment, and sometimes the bony edge of the glenoid cavity, is inspected. The glenoid rim is then roughened with a chisel or a curette. The scapular margin of the cut capsule is grasped at each corner with an Allis clamp and placed over the defect in the glenoid rim. This is fixed firmly in place by a stainless-steel staple, one-half inch in width and three-quarters of an inch in length; the staple is inserted with a special instrument and directed slightly toward the body and spine of the scapula. Before the staple is firmly set, its location and position are inspected through the capsular incision; if these are not correct, the staple can easily be withdrawn by the same instrument and reinserted (Fig. 3). The humeral edge of the capsular incision is now plicated over the scapular edge and fixed with two or three interrupted chromic sutures. This builds up and firmly fixes the glenoid rim, and it also shortens the antero-inferior portion of the joint capsule. The subscapularis tendon is resutured to its tendinous insertion with chromic sutures, and the remainder of the wound may be closed easily (Fig. 4).

FIG. 4

Postoperative roentgenogram, showing the staple in position.

POSTOPERATIVE TREATMENT

The arm is strapped to the side for two weeks, and an arm sling is worn for an additional week. Active exercises are then started, and are increased as recovery pro-

gresses. By the end of six weeks, as a rule, 90 degrees of active abduction can be obtained. It usually takes from eight to twelve weeks before the normal range of shoulder motion is restored.

RESULTS

The staple method of capsular fixation has been used in twenty-four cases. The first patient, a Fireman Third Class, aged twenty-one, was operated upon September 21, 1943, at the United States Naval Hospital, Mare Island, California, and returned to full duty in less than eight weeks. There has been no known recurrence in any case. A slight limitation of external rotation may persist, but this has never been a cause for complaint.

The end results and comparative results of the major portion of this series are reported by Myers.

The author has also fixed the capsule to the rim of the glenoid by means of two or three stainless-steel nails, according to the method of Toffelmier, and by the use of a vitallium screw; but he prefers the staple.

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EXPERIENCE WITH CAPSULORRHAPHY FOR RECURRENT DISLOCATION OF THE SHOULDER

BY CAPTAIN ORRIS R. MYERS

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Experience in the Armed Forces during the past four years has increased our knowledge of recurrent dislocations of the shoulder, and has afforded an excellent opportunity to study, analyze, and evaluate this particular entity.

The shoulder joint is a ball-and-socket joint which is subjected to a greater range of motion than other anatomical joints. It is held in place by a capsule, which is supported by a musculotendinous cuff throughout its entire girdle, except on the inferior aspect. Neviaser's anatomical description reveals this defect, which has been a pertinent factor in the present series of cases. Eyre-Brook has found, from dissections of twenty-one shoulders, that the superior and inferior glenohumeral ligaments are usually of considerable size and strength; and that the anterior capsule is always attached to the lip of the glenoid cavity and never to the neck of the scapula. This has been demonstrated by injecting lipiodol into the shoulder joint. The opening of the subscapular bursa is well away from the rim of the glenoid cavity and, therefore, cannot be confused with capsular detachment. The glenoid cavity is small and shallow, and only one-fourth of the articular surface of the humeral head is in contact with it at any time. The periphery consists of a fibrocartilaginous ring,—the glenoidal labrum. It is triangular in shape with a base attached by a dense fibrous tissue to the bone of the glenoid rim; one surface is in contact with the articular cartilage of the humerus, and the other is in contact with the capsule. A shallow sulcus intervenes—the subscapular recess—which is crossed by superior, middle, and inferior glenohumeral ligaments. This reflected fold of the capsule, with the synovial membrane lining its inner surface, must not be mistaken for detachment of the capsule.

When sufficient trauma has been exerted, the head is forced anteriorly or inferiorly (subglenoid) over the vulnerable sector of the glenoid rim, since the remainder of the joint is supported by the intimate union of the tendons of the supraspinatus, infraspinatus, teres minor, and subscapularis muscles, and joint opposition can no longer be maintained at this point. The capsule is detached, with the fibrocartilaginous ring, or the labrum is fractured, or both, by the impact of the head of the humerus. Not infrequently the head of the humerus itself sustains injury. This detachment of fibrocartilaginous tissue with associated fracture or damage is difficult to repair and defects persist, whereas capsular tears in ordinary dislocations heal promptly.

Watson-Jones states that two essential features have escaped general observation for many years. The first is injury to the glenoid fibrocartilage, which is not disclosed by routine exposure of the joint and can be displayed only by special dissection. The second is injury to the head of the humerus, which is not visible in routine roentgenograms and is shown only in special projections.

Consequently, this detachment of the capsule and labrum, its fracture, the defect in the posterolateral sector of the head of the humerus, and the resulting capsular laxity permit the head to slip easily over the glenoid rim while still remaining intracapsular. This explains the facility with which so many dislocations are reduced by patients themselves, and the frequency with which individuals complain that the joint, although not actually dislocated, has "slipped", "given way", or momentarily "locked".

Bost and Inman have described the pathological changes of erosion, fracture, and defect of the glenoid rim. Proof that the two injuries of the head and of the rim were sustained simultaneously, by the impact of one bone against the other, is seen in the accurate fitting of the posterior defect of the head with the defect of the anterior rim of the glenoid.

TABLE I

EVALUATION OF THIRTY-ONE CASES

Case No.	Patient	Age	Type of Dislocation	Treatment of Coracoid	Section of Subscapularis	Capsule Incision	Pathological Changes			Capsule Fixation	End Results		
							Capsule	Labrum	Osteochondritis		Limitation of Motion	Functional Defect	Disposition
1	W. M. K.	24	Anterior glenoid	Excision	Total	Parallel to rim	Redundant	Fractured	Rim	Suture	25% in all planes	35%	S
2	W. M. K.	24	Posterior luxation			Parallel to rim	Detached	Fractured		Suture	25% in all planes		
3	H. K. J.	28	Anterior glenoid	Excision	Total	Parallel to rim		Fractured	Glenoid	Suture	Sl. abd. and ext. rot.	None	LD
4	L. E. S.	21	Subglenoid	Excision	Total	Parallel to rim	Detached	Fractured	Glenoid fossa	Suture	Sl. abd. and ext. rot.	None	S
5	R. B.	23	Anterior and subglenoid	Excision	Total	Parallel to rim	Detached	Fractured, 2½ cm.	Defect of rim	Suture	20% in all planes	15%	LD
6	D. G. B.	27	Subglenoid	Excision	Total	Parallel to rim	Tear of supraspinatus	Fractured		Suture	10% in all planes	15%	S
7	H. G. F.	26	Anterior and subglenoid	Excision	Partial	Parallel to rim	Detached	Fractured		Suture	Sl. ext. rot.	None	D
8	F. G. C.	31	Subglenoid	Left intact	Partial	Parallel to rim	Detached	Fractured		Staple	Sl. ext. rot.	None	LD
9	W. H. W.	19	Subglenoid	Excision	Partial	Parallel to rim	Detached	Fractured	Rim	Suture	Sl. ext. rot.	None	LD
10	D. C. C.	21	Anterior and subglenoid	Excision	Partial	Parallel to rim	Tear, detached	Fractured		Suture	Sl. ext. rot.	None	D
11	R. H.	36	Anterior and subglenoid	Excision	Partial	Parallel to rim	Detached	Fractured	Fossa	Suture	Sl. ext. rot.	None	D
12	G. B. B.	25	Anterior and subglenoid	Left intact	Partial	Parallel to rim	Detached	Fractured		Staple	Sl. ext. rot. and abd.	None	S
13	G. S.	26	Anterior and subglenoid	Excision	Total	Parallel to rim	Detached	Fractured	Defect of rim	Staple and suture	Sl. ext. rot.	None	LD
14	P. R.	24	Anterior and subglenoid	Left intact	Partial	None	Detached		Defect of rim	Staple	10% ext. rot. and abd.	10%	S
15	R. W. T.	40	Anterior and subglenoid	Excision	Total	Parallel to rim	Detached	Fractured	Arthritis of head	Two staples	30% in all planes	50%	S

15	R. W. T.	40	Anterior and subglenoid	Excision	Total	Parallel to rim			of head	staples	planes		
16	R. E. H.	22	Anterior and subglenoid	Excision	Partial	Parallel to rim	Detached	Fractured		Suture	Sl. ext. rot.	None	D
17	W. E. T.	29	Anterior and subglenoid	Left intact	Partial	Parallel to rim	Detached			Staple	Very sl. ext. rot.	None	D
18	A. Y.	24	Anterior and subglenoid	Excision	Partial	Parallel to rim	Detached	Detached		Staple	Sl. ext. rot.	None	D
19	C. S. C.	26	Subglenoid	Excision	Partial	Parallel to rim	Detached	Fractured	Rim and fossa	Staple	10% ext. rot.	5%	S
20	A. S.	32	Anterior and subglenoid	Excision	Partial	Parallel to rim	Detached	Fractured		Staple and suture	10% abd. and ext. rot.	10%	S
21	A. R. G.	19	Anterior and subglenoid	Excision	Partial	Vertical to rim	Detached			Suture and staple	15% in all planes	20%	S
22	B. M.	22	Anterior and subglenoid	Excision	Partial	Parallel to rim	Tear of supra-spinatus	Fractured		Suture	Sl. ext. rot.	None	S
23	R. C. M.	32	Anterior and subglenoid	Excision	Partial	Parallel to rim	Detached	Fractured	Defect of rim and head	Suture	10% ext. rot.	None	S
24	R. E. S.	26	Subglenoid	Excision	Partial	Parallel to rim	Detached		Rim	Suture and staple	Sl. ext. rot.	None	S
25	S. C. S.	18	Subglenoid	Intact	Partial	Parallel to rim		Fractured		Staple	None	None	D
26	D. L. T.	32	Anterior and subglenoid	Intact	Partial	Parallel to rim	Redundant, detached			Suture and staple	35% in all planes	50%	S
27	L. D. B.	40	Anterior and subglenoid	Excision	Partial	Parallel to rim	Detached, redundant	Fractured	Defect of rim	Suture and staple	Sl. ext. rot.	None	D
28	C. A. F.	20	Subglenoid	Excision	Partial	Parallel to rim	Redundant, detached		Rim	Suture and staple	Sl. ext. rot.	None	D
29	C. R. P.	20	Posterior luxation			Parallel to rim	Detached	Fractured		Suture and staple	Sl. ext. rot.	None	D
30	G. R. S.	20	Posterior luxation			Parallel to rim		Detached	Labrum, rim	Suture and staple		Under treatment	
31	K. A. H.	19	Posterior luxation			Parallel to rim		Notched rim	Labrum	Suture and staple		Under treatment	
Summary:							Detached 84%	Fractured 73%	Present in 48%			None in 66% 15% in 23% 50% or more in 7%	

S = Surveyed from Service (41%; all but three could do limited duty)
LD = Limited duty (17%)
D = Discharged to full duty (38%)

This series represents about 50 per cent. of the cases of recurrent dislocation seen on the Orthopaedic Service of this Hospital. There were ten patients with recurrent dislocation after a Nicola operation, a tenosuspension operation, or both, who refused further surgery. The remainder of the cases were either E.P.T.E. (existing prior to enlistment) or the patients refused operation and were discharged from the Armed Forces by a Board of Medical Survey. No cases of recurrence following the Bankart operation were seen on this Service. Some authorities claim that dislocation will recur, if at all, within one year of operation. This has not been borne out by observations on this Service.

With these facts in mind, it was decided to use an approach and a procedure similar to those described by Bankart, in order to find a better solution to the problem.

OPERATIVE TECHNIQUE

An anterior incision is used, extending from the tip of the coracoid process distally for six inches along the depression or groove between the deltoid and the pectoralis major. A dissection of the muscle plane is made between the deltoid and pectoralis muscles, and the deltoid is retracted laterally with the cephalic vein. The cephalic vein is used as a guide to muscle dissection. The short head of the biceps and the coracobrachialis muscles are exposed and are freed along the lateral border. No dissection is made along the medial plane, except at the coracoid attachment, in order to avoid trauma to vessels and nerves. The tip of the coracoid, including its muscle attachment, is excised with a sharp osteotome. When the attached muscles have been retracted medially, the subscapularis muscle comes into view. The inferior border of the subscapularis musculotendinous portion is exposed. Care should be used to avoid trauma to the circumflex vessels and nerves which cross at this level above the teres major. The blunt dissection upward is started at the medial axillary foramen. The lower halves of the musculotendinous structures are dissected from the capsule, with which they are intimately associated at this point. Retracting sutures of heavy chromic catgut are placed in the medial portion of the cut muscle, and also in the tendinous portion near the lesser tuberosity. The muscle portion is retracted medially and the capsule comes into full view, with the anterior rim of the glenoid in the center of the field. Two Allis forceps grasp the capsule one inch apart, just above the rim of the glenoid; by a sharp scalpel with an offset blade, a longitudinal incision parallel to the rim is made in the capsule. It is imperative that this incision follow the rim and that it be no longer than is necessary for exploration and fixation. The joint margin is explored and the pathological changes are determined. In all cases the labrum or the capsule was found to be detached. Loose fragments of osteochondritic origin, including fragments of the labrum, when fractured, are removed from the joint. With a narrow chisel the edge of the rim is cubed to provide a surface of raw bone.

With the first cases, a harness awl, with a triangular point bent at an angle of 45 degrees, was used to make the holes from the articular cartilage of the glenoid through the bony rim. Mattress sutures of nylon were carried by a short stout needle through these holes into the lateral free flap or capsule of the humerus, approximating it with the entire area of denuded rim. The medial scapular flap was plicated over the lateral flap by two or three fine silk sutures. In order to get these sutures well placed, an assistant must exert backward and outward retraction on the upper arm to get the humeral head away from the glenoid cavity and rim. After the sutures are made in the capsule, the head of the humerus is allowed to return to the glenoid fossa and is placed in internal rotation. The subscapularis is sutured, the coracoid tip is sutured into position, and the wound is closed with as few sutures as are necessary for tissue approximation.

Downing fixed the scapular margin of the cut capsule to the rim of the glenoid by a stainless-steel staple made from a Kirschner wire. The lateral edge of the capsule was sutured to the fixed scapular edge with mattress sutures, thus everting the cut edges of the

TABLE II

COMPARATIVE STUDY OF CAPSULE FIXATION

End Results	Capsule Sutured (*Per cent.*)	Capsule Stapled (*Per cent.*)
No functional defect	73	62
Defect of more than 15 per cent.	18	37
Discharged to full duty	36.5	41
Discharged to limited duty	27	12
Surveyed from Service	36.5	47

capsule and eliminating any intracapsular raw edges of tissue. This resulted in building up as well as fixation of the glenoid rim. Downing devised a special instrument for inserting the staple and for retracting the subscapularis, and claimed that it was not necessary to remove the tip of the coracoid or to section the subscapularis completely for adequate exposure. By this method, which was used in the later cases of the series, the operative time was considerably shortened and the surgical trauma was lessened, although no difference could be noted in the end results from those obtained by the classical Bankart procedure (Table II).

The patients with posterior dislocations were operated upon, by use of the approach described by Rowe and Yee, which gives a very fine exposure of the posterior rim. In each of these cases, a detachment of the capsule for a distance of three centimeters was noted, and the labrum was fractured; one had a loose fragment attached to the rim by a shred of tissue. The first case was treated by suturing the capsule flap to the raw bone edge; a dental drill was used for the holes. In the other cases a stainless-steel staple was used to fix the lateral or free flap of the capsule to the raw bone rim; eversion of the edges of the capsule was accomplished with mattress sutures.

In five cases of this series the coracoid tip was not excised. The short biceps and coracobrachialis muscles were retracted medially. No difference could be noted in the end result (Table I).

The first patient selected had virtually a flail shoulder, and he could slip the humeral head over the anterior or posterior rim of the glenoid at will. He had a posterior as well as an anterior subglenoid type of dislocation. The patient had had two previous operations, first a Nicola operation and later a Henderson tenosuspension, without correction of the disability. A fusion of the shoulder joint had been advised prior to his transfer to this Hospital. The classical pathological changes in this case were those that have been described by various writers. Interest was further stimulated by the stability of the joint following the anterior capsulorrhaphy, so that the posterior procedure also was carried out at a later date. The results of these two operations for anterior and posterior repair were gratifying. Because of the complications and the perplexing problems, the following cases are reported in detail.

CASE REPORTS

CASE 1. W. M. K., a white male Seaman, Second Class, aged twenty-four years, was admitted to the United States Naval Hospital on July 15, 1944, for treatment and disposition. His original injury, in 1942, was a fall of ten feet from the gangway of a ship, causing a complete subglenoid dislocation of the left shoulder; this necessitated anaesthesia and a difficult manipulation for reduction. Six weeks after injury the shoulder became dislocated while the patient was taking a shower. Reduction was made without anaesthesia and a sling was worn for two weeks. Subsequently, the shoulder dislocated frequently upon throwing the arm forward, or lifting with the arm in abduction and external rotation. After several episodes it was noted that internal rotation of the arm and reaching backward would cause a posterior slipping of the humeral head.

In October 1943, a Nicola operation was performed at a Naval hospital. Postoperative recovery was uneventful. Atrophy of the deltoid followed, with weakness of the shoulder girdle. While physiotherapy and active motion were being conducted, three months after operation, the shoulder dislocated

anteriorly. The shoulder joint was very much relaxed, and the patient could again slide the humeral head forward or backward over the glenoid rim. He was evacuated to a United States Naval Hospital in the continental United States for disposition. In January 1944, a Henderson tenosuspension was performed at that Hospital by a competent orthopaedic surgeon. After this operation, the shoulder felt weak and insecure. The patient stated that he could feel no change in the shoulder joint, and when active motion was resumed he noticed the same anterior and posterior subluxation. For several months he received physiotherapy and exercise without any improvement, and was sent to this Hospital for disposition. A shoulder fusion had previously been advised.

Physical examination revealed a tall, slender individual with comparatively poor muscle development and stooped posture. There was marked atrophy of the left shoulder girdle, particularly of the entire deltoid. There was a well-healed incision, eight centimeters in length, over the anterolateral aspect of the shoulder; and a second well-healed incision over the lateral aspect, extending distally from the acromion process for from eight to ten centimeters. Anterior elevation and abduction were slow and unsteady, with a comparative loss of 50 per cent. External and internal rotation were about the same as on the right, but subluxation of the humeral head occurred anteriorly and posteriorly, respectively. The patient could not lift more than ten or fifteen pounds with the left arm.

On August 2, 1944, an anterior Bankart operation was performed under gas-oxygen-ether anaesthesia, using the approach previously described. The operative findings disclosed a redundant thickened capsule, which was entirely detached from the glenoid rim over two thirds of the anterior rim; and a fracture of the labrum, with a loose piece three centimeters in length attached to the capsule. On the superior border of the capsule there was a vertical tear, three centimeters in length. The loose fragment was removed. The lateral or free flap of the capsule was sutured to the raw bone edge of the glenoid rim with nylon sutures. The rent in the capsule was sutured with No. 00 chromic catgut. The coracoid tip, with its muscle attachments, was sutured into position and the wound was closed without drainage. A Velpeau dressing was applied. Postoperative convalescence was uneventful, and motion was started on the twenty-first day. The anterior capsule appeared to be tight, and the head could not be dislocated anteriorly. However, the humeral head could be displaced posteriorly over the posterior glenoid rim.

On September 8, 1944, a posterior Bankart operation was performed, by use of the posterior approach described by Rowe and Yee. The operative findings disclosed a detachment of the capsule from the posterior glenoid rim, and a fracture defect three and one-half centimeters in length. The fragment was removed, the rim was denuded over the defect, and the free flap of capsule was sutured to the rim with nylon and plication of the scapular flap of capsule. The wound was closed in layers. A Velpeau dressing was applied to the arm and a sponge rubber doughnut ring was placed over the posterior aspect of the humeral head. The postoperative period was relatively free from pain; the highest temperature was 100.2 degrees on the second day after operation. There was no drainage from the wounds, which healed by first intention.

Active motion was started on the twenty-first day, using the Codman procedure of circumduction and later the shoulder-girdle exercises.

The patient was hospitalized under treatment for a further period of three months. There remained a limitation in external and internal rotation and abduction; the latter was due largely to the atrophy of the deltoid which had been present upon admission. Seventy-five per cent. of the normal range of motion was present, although the motor power of the entire shoulder girdle was weakened. No recurrence of dislocation or subluxation had taken place when the patient was discharged from the Naval Service on January 2, 1945.

CASE 6. D. G. B., a white male Machinist's Mate, Second Class, aged twenty-seven years, was admitted to the United States Naval Hospital on February 4, 1944, for treatment and disposition. His original injury was sustained on September 10, 1942, when a dock crane tipped and he was thrown backward, falling on his extended arm. A subglenoid dislocation occurred with a sliver fracture of the greater tuberosity. Reduction was accomplished under anaesthesia, and a sling was worn for three weeks. Subsequently, the patient stated he had had frequent dislocations, totaling about fifty. On February 8, 1944, a Nicola operation was performed. No dislocation occurred, but the patient had a limitation of abduction and anterior elevation, with pain. He was discharged to limited duty. On July 5, 1944, he slipped, and in catching himself, dislocated the shoulder. No anaesthesia was required for reduction. On July 11, 1944, examination disclosed a loss of 35 degrees in anterior elevation, 25 degrees in abduction, and 10 degrees in internal and external rotation, with pain. Several dislocations followed.

On September 27, 1944, a Bankart capsulorrhaphy was performed from the usual approach, including section of the coracoid tip and the tendon of the subscapularis muscle. There were dense adhesions with extensive oozing, and the muscle planes were difficult to follow. The operative findings revealed a T-shaped tear in the anterosuperior portion of the capsule, and a tear of the glenohumeral ligament. There was a fracture of the labrum on the inferior border, although the capsule was not detached except for a small area at the site of fracture. The biceps tendon was intact but appeared to be stretched. The tear in the capsule was sutured with fine chromic catgut. The lateral flap of the capsule was sutured to

FIG. 1-A

Case 29. Roentgenogram taken with arm in abduction. The head is in normal opposition to the glenoid cavity.

FIG. 1-B

Roentgenogram taken with arm in abduction and internal rotation. This position produces posterior subluxation of the humeral head over the rim of the glenoid. Note relaxation of the capsule to permit the wide joint space, and the increased space between acromion and greater tuberosity.

the raw bone rim with nylon, mattress sutures, and plication of the medial flap. For two weeks, dressings were performed with the arm on a 45-degree abduction splint, and then a sling was worn for three weeks. There was severe pain for the first five days. On the sixth day the patient's temperature rose to 102 degrees and a large hematoma was evacuated from the lower end of the incision. Drainage continued for a few days and healing was complete at the end of three weeks, at which time motion was started. Physiotherapy and active motion were continued.

On October 30, 1944, the patient was transferred to a convalescent hospital. On November 20, 1944, while he was receiving physiotherapy and manipulation, the lower end of the wound opened and fresh bleeding occurred. The wound again healed, after a slight serous drainage for three weeks. Motion at that time showed a loss of 10 degrees of external rotation, 30 degrees of abduction, 70 degrees of anterior elevation, and a 10 per cent. limitation of circumduction. Physiotherapy was continued; improvement followed. There was considerable pain in the extremes of all motions.

FIG. 1-C

Roentgenogram three weeks after operation, showing staple in posterior rim of glenoid, and humeral head in normal relation to glenoid.

The patient was discharged from the Service in March 1945, with a range of motion which was about 90 per cent. of normal, but which was painful in abduction and external rotation. There was some keloid of the operative scar, for which roentgenotherapy was given prior to discharge from the Hospital.

CASE 29. C. R. P., a white male Corporal in the United States Marine Corps, aged twenty years, was admitted to the United States Naval Hospital on July 18, 1945, for treatment of recurrent dislocation of the right shoulder. His first injury was sustained in 1940, while he was playing football. The dislocation was reduced without anaesthesia by a doctor at the athletic field. There was no recurrence until a second injury occurred in 1943, when the patient fell from the tail gate of a moving truck. His dislocation was reduced by a hospital corpsman without anaesthesia. The description given was a posterior subluxation; both injuries occurred while the arm was internally rotated and abducted. Since the injury in 1943, the patient had noticed a relaxation of the joint, and he could subluxate the humeral head over the posterior glenoid rim at will.

Examination revealed a well-developed, slender individual with no unusual joint relaxation except of the right shoulder. There was a full range of scapulohumeral motion of the right shoulder, and the patient could demonstrate a posterior subluxation of the head by internal rotation and abduction of the arm. The head could be palpated while sliding over the rim; this was verified by fluoroscope and by roentgenogram (Figs. 1-A and 1-B).

On August 28, 1945, a Bankart capsulorrhaphy was performed, with the posterior approach. Operative findings disclosed a detached capsule and a fracture of the labrum and rim, on the posterior sector. The scapular edge of the cut capsule was stapled to the posterior glenoid rim, and the humeral edge of the capsule was plicated over this and sutured with chromic catgut. Recovery was uneventful. Motion was started on the twenty-first day, and consisted of physiotherapy and active exercises. Seventy-five per cent. of motion was present (Fig. 1-C).

Examination on October 4, 1945, revealed a well-healed scar over the posterior aspect of the shoulder joint, with slight deltoid atrophy. Extension and flexion were the same as on the left. Abduction was equal to that on the left. Anterior elevation was 15 degrees less than on the left. Internal rotation had a few degrees of limitation. External rotation was almost equal to that on the left. With the arm in internal rotation and abduction, the head could be subluxated or slipped over the posterior rim. There was slight weakness in the muscle power of the shoulder girdle. The range of motion was 95 per cent. of normal. The patient will be discharged to duty.

A Velpeau dressing was used in all cases, and the upper arm was secured to the body for a period of fourteen days to prevent external rotation and abduction. The patients were permitted bathroom privileges after five days, and were confined to the ward for ten days. Motion was started about the twenty-first day, and only a sling was used. Circumduction, in the manner described by Codman for postoperative shoulder cases, was started at this time. Carefully supervised physiotherapy was used on all patients until a maximum range of motion was obtained.

All patients had sufficiently recovered to be discharged from the hospital at the end of from ten to fourteen days, but military routine necessitated hospitalization until they were fit for duty. Twenty-seven of these patients could have returned to light duty at the end of four weeks, or could have returned to office work after fourteen days. No limited duty was available at the time of convalescence for most of these patients; consequently, the period of disability is of no value statistically.

Trauma was found to be a very definite factor in this series; trauma from accident or injury occurred in twenty-nine cases, or 97 per cent. Repeated accidents or traumata were found in 50 per cent. of the cases. The one epileptic could not recall any accident; the first dislocation occurred during an attack of petit mal.

The dislocations were predominantly of the anterior and subglenoid type; there were six cases of each, and fourteen cases which combined the two types. Four were posterior, and one of these combined all three types.

The pathological findings were conclusive: all of the cases had a detachment of the capsule from the rim at the site of the fracture or defect. There were twenty-one cases, or 73 per cent., with a fracture of the labrum. Fifteen cases presented osteochondritic or degenerative changes of the humeral head, with a typical osteochondritis dissecans, one centimeter in diameter, lying in the joint cavity. Eight cases had a definite notch defect in the rim, demonstrable by roentgenogram. Only one case with a defect of posterior notching of the humeral head was noted. One case had a hatchet-shaped deformity of the head, attributed to a fracture sustained several years prior to operation.

In four cases dislocation had recurred after the Nicola operation; one of the patients had had a tenosuspension operation after the Nicola operation, with recurrence. Three cases had definite tears or defects in the superior border of the capsule, involving the musculotendinous cuff, as described by McLaughlin.

CONCLUSIONS

Inasmuch as approximately sixty different operations have been devised for the treatment of recurrent dislocation of the shoulder, each productive of a degree of success, it would appear that to date there has been no wholly dependable operation for complete cure of this malady.

The present series would indicate that we must attack the site of pathological changes in order to procure a more satisfactory result, and since the changes seem to be constant

in the capsule and the joint cavity, a method of capsulorrhaphy would be the most logical therapeutic measure.

Compensatory muscle, tendon, or fascial support has not been found adequate in these cases, nor has their plastic repair or substitution been sufficient.

This method of capsulorrhaphy causes no intra-articular damage, the joint cavity remains intact with no more trauma than is produced by the arthrotomy, and the repair is made at the site of trauma with an attempt to overcome the insufficiency of the glenoid cavity.

The incidence of recurrence must be evaluated after a period of years, rather than of months, in order to determine the final proof of any one procedure. Eighteen months without recurrence has been the longest period of observation made by the author.

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ROTATION OSTEOTOMY

A Method Employed in Cases of Congenital Club-Foot

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In the newborn, there is normally an inward rotation of the foot, which may be measured by the angle formed by the transverse axes of the ankle joint and the knee joint. The inward rotation in the newborn is normally considered to be 10 degrees. A continuous outward rotation of the foot usually takes place during growth, so that the two axes are parallel at the age of ten. In adults, the axis of the ankle joint is rotated 23 degrees outward in relation to that of the knee joint.[5]

It is a well-known fact that inward rotation is increased in most patients with congenital club-foot. This increased inward rotation must be considered a "normal" component in the type of foot deformity which is called talipes equinovarus congenitalis. The inward rotation in congenital club-foot is reported to be as much as 40 degrees or more.

Compared with the other faulty positions which make up the deformity called club-foot (talipes varus, talipes adductus, and talipes equinus), the increased inward rotation and its treatment have not attracted much interest. This may be ascribed partly to the fact that an inward rotation is not so conspicuous as other faulty positions, and partly to the circumstance that this deformity may have been considered less important from the point of view of therapy and prognosis than the equinus, varus, and adductus deformities. Even if the last-mentioned point of view may seem warranted to a certain extent, an increased inward rotation cannot be considered entirely unimportant. If it remains after the other deformities have been corrected, the patient will propel his foot over its lateral border when walking. In the last phase of a step, the foot is thus forced into varus position. This entails a bad gait and a risk of recurrence of a varus deformity which had been well corrected; and in these cases, this is a considerable risk. In patients with remaining inward rotation of the foot, especially where this rotation is great, the peroneal muscles are lengthened and the anterior tibial muscle is shortened; a state of contraction in the anterior tibial muscle, resulting in an increased varus tendency, may thus easily be produced.

The treatment of increased inward rotation may be either conservative or operative.

Conservative treatment is carried out either as a part of the plaster correction of the equinovarus position, or, later, by means of mechanical devices. A number of such apparatus, more or less complicated, have been constructed.[3] The method employing the spiral bar constructed by Heusner is in most general use today.[12]

Several methods have been suggested for operative correction of inward rotation. All of these methods recommend a transverse osteotomy of the tibia at its *lower third*,[1,3,6] in most cases followed by transverse osteotomy or osteoclasis of the fibula at the same level. Some authors[7,8,11] have performed osteotomy of the tibia only. Others have proposed either a transverse osteotomy at the *middle* of the tibia without osteotomy of the fibula,[2] or osteotomy of the lower part of the femur.[8] Stirling describes a method with oblique osteotomy at the middle of the tibia, while the fibula is left intact. After the osteotomy, the inward rotation is corrected, and plaster is applied from the toes to the groin. The plaster is kept in position for from four to six weeks.

There are certain disadvantages to all of these operations. If the operation is limited to osteotomy of the tibia, an inward rotation cannot be entirely corrected. The medial malleolus rotates with the distal end of the tibia, while the lateral malleolus remains unchanged. For this reason, the joint surfaces of the malleoli are no longer congruent with the joint surfaces of the lateral and medial part of the astragalus. This may limit move-

ment of the ankle joint, and increases the risk of recurrence. Similar results are obtained in patients in whom osteoclasis of the fibula has been performed, in addition to osteotomy of the tibia.

Where osteotomy or even resection of the fibula has been done at the same level as osteotomy of the tibia, it is possible to produce a real derotation. There is, however, a risk that a faulty position at the site of the osteotomy may be obtained, coincident with correction of the inward rotation.

In order to eliminate the difficulties mentioned, the following method for performing rotation osteotomies has been employed by the author since 1940. So far as is known, this method has not been described. The operations have been carried out at the Vanföreanstalt in Gothenburg and at the Orthopaedic Clinic in Lund.

A transverse osteotomy is made subperiosteally within the lower third of the tibia. Then an oblique osteotomy of the fibula is made within its upper third. In order to avoid injuring the peroneal nerve, the osteotomy should not be too close to the neck of the fibula. The incision is best made over the anterior intermuscular septum which divides the extensor digitorum longus from the peroneal muscles. The incision should then continue behind the septum, as this is the best way of reaching the fibula. At this level the superficial peroneal nerve runs along the short peroneal muscle, but it is not difficult to avoid. The osteotomy of the fibula should also be made subperiosteally, and care should be taken to ascertain that the periosteum is well elevated from the back of the fibula to prevent a lesion of the posterior fibular artery. As a matter of fact, the posterior *tibial* artery may sometimes be missing or run along the back of the tibia as an unimportant vessel, and in such cases the posterior *fibular* artery has to carry the whole burden of supplying the vascular area of the tibial artery. After the osteotomy, a full-length leg cast is applied and maintained for six weeks.

This operative procedure affords the following advantages: (1) The risk of faulty positions in the tibial osteotomy is practically eliminated, as the fibula, untouched in its lower part, serves as a stabilizer. (2) A real derotation of the foot can be performed with maintained congruence between the joint surfaces of the malleoli and the sides of the astragalus. (3) It is easier for the surgeon to control the derotation by this method than by other methods. The correction is easily made, and no violence is necessary even in patients with very high degrees of inward rotation. The degree of correction is easily adjusted to the demands in the individual case.

At the Vanföreanstalt in Gothenburg and at the Orthopaedic Clinic in Lund, the writer has performed seventeen rotation osteotomies on thirteen patients, according to this method, since 1940. Of these patients, eight have been observed for from two to two and a half years, and five for from three to four years following operation. No recurrence of inward rotation has taken place, and the position of the feet has been very good in all cases.

Rotation osteotomy is indicated principally in cases in which the equinus, varus, and adductus deformities have already been corrected; but where, in spite of this, an increased inward rotation remains, so that the patient propels his foot over its lateral border. This also implies that rotation osteotomy should be resorted to only when the correction possible by conservative treatment has been completed, and after other operative measures, such as achillotenotomy, have been undertaken.

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DEFORMITIES FOLLOWING SURGICAL EPIPHYSEAL ARREST

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Reports on lengthening and other methods of equalizing the length of the lower extremities when discrepancies occur after infections, trauma, congenital deformities, and paralyses in children stimulated Phalen and Chatterton to review their cases at the Gillette State Hospital in which operations for lengthening and shortening the lower extremities had been performed. The authors have undertaken a review of the cases of epiphyseal arrest for unequal limb length, because of a number of deformities which were observed in the Out-Patient Clinic of the same Hospital in patients who had undergone this surgical arrest of growth in the lower extremities.

EQUALIZATION OF LENGTH OF THE LOWER EXTREMITIES

Discrepancy in the length of the lower extremities may become a disability severe enough to warrant surgical intervention, depending upon the amount of difference in the length of the two limbs. In differences of one inch (2.5 centimeters) or less, compensatory motion of the pelvis and spinal column usually takes care of the discrepancy. Shortening of a limb of more than one inch usually leads to excessive tilting and curvature of the spinal column, with resultant muscular fatigue and symptoms of strain. Furthermore, the psychic effect of a short limb and conspicuous appliances, such as lifts or pattens on the shoe, usually prompts either the patient or his parents to seek relief for the condition.

Inequality in limb length may be caused either by retarded growth or by increased growth in the extremity. Loss of bone substance following accidents may also terminate in limbs of unequal length. The growth of bone may be altered by various diseases of bone, such as rickets and acute and chronic infections in or about the metaphysis. Trauma, the action of various endocrine glands, and various affections of the nervous system may also alter the structural growth of bones. Congenital deformities of bones and joints, as well as benign bone tumors and acquired or congenital vascular conditions, may be factors in producing inequality of growing bones.

One of the most common types of overgrowth in bone is that resulting from chronic osteomyelitis in the juxta-epiphyseal region of the long bones, even without actual invasion of the epiphyseal cartilage itself. It has been noted by many observers that retardation, rather than stimulation, of growth of epiphyseal cartilage usually results from minimum trauma or epiphyseal invasion by avirulent micro-organisms.

Attempts have been made to equalize the length of extremities, while growth is still in progress, by stimulation as well as by retardation. Although Wilson and Thompson have reviewed the literature and have given an excellent critical analysis of the methods available to equalize limb lengths, a few notes as to the historical background may be necessary.

As early as 1867, Ollier observed that irritation of the shaft of a growing bone resulted in an increase in the rate of growth.

After sympathectomy, which had been done primarily to enhance the blood supply to the limbs, Harris noted an increase in the growth of extremities which were paralyzed following acute poliomyelitis and showed variations in the vasomotor supply, manifested by coldness, changes in color, and paraesthesia. The epiphyseal growth was stimulated

TABLE I

ETIOLOGY OF DISCREPANCIES IN THE LENGTH OF THE LOWER EXTREMITIES

Etiological Factor	Number of Cases
Anterior poliomyelitis	24
Congenital shortening	3
Septic arthritis	
Hip	1
Ankle	1
"Infectious process involving epiphysis of knee"	1
Spina bifida	1
Tuberculosis	
Hip	1
Knee	1
Epiphysiolysis of hip	1
Chronic osteomyelitis with overgrowth	2
Total	36

with the increase in circulation to the extremity. Wilson and Thompson, in a later report, found that the increase in rate of growth was too slight and too inconstant to justify recommending sympathectomy as a method of equalizing limb length.

Brooks and Hillstrom have shown that growth of the cartilage cells of the epiphyses can be delayed or completely inhibited by exposure to roentgen rays. Clinically, however, serious damage to the articular structures seems almost inevitable.

It remained for Phemister to report a method of attempting the limitation of growth of the longitudinal bone by surgically disrupting the growing epiphyses of the longer limb when unilateral shortening or lengthening had occurred.

The decision as to when the arrest should be performed is more difficult than the actual technique of operative procedure. Also, the epiphyses to be fused must be considered. It is possible to produce overshortening in the extremity upon which operation is performed, since the epiphyses of the short limb may still produce sufficient growth, although it has been diminished, to overtake the extremity which has been arrested to too great an extent. Straub, Thompson, and Wilson have recorded such a case.

Digby determined the average proportional growth at various epiphyseal lines, and his calculations are used by many surgeons in determining their operative sites. Certain complicated methods have been propounded for determining the optimum age for operation and the sites for fusion.

White and Stubbins stated that, regardless of the age and size of the growing patient, arrest of growth of the distal femoral epiphysis retards growth at the rate of three-eighths of an inch (1 centimeter) a year, while arrest at the proximal end of the tibia (and of the fibula) retards growth one-quarter inch (0.6 centimeter) a year. They also mentioned an important item,—namely, that epiphyseal growth ceases in girls at sixteen years of age and in boys one year later. They recommended that epiphyseal arrest be performed in children at the age of ten or twelve years, if there is a shortening of more than two inches (5 centimeters), so that by the time growth ceases, approximate equalization can be expected.

Wilson and Thompson stated that, if only a moderate retardation of growth seems indicated, the decision as to whether epiphyseal arrest should be performed above or below the knee depends on whether the shortening in the opposite extremity is greater in the thigh or in the leg.

Objections to epiphyseal arrest, as to some other methods of equalizing limb length, arise because of the necessity of surgically attacking the uninvolved extremity and in so doing, subjecting it to the possible risks attendant upon any surgical procedure.

TABLE II

DATA ON THIRTY-SIX CASES OF SURGICAL EPIPHYSEAL ARREST

Bones in Which Epiphyses Were Arrested	Age at Time of Arrest (*Years*)	Discrepancy at Time of Arrest (*Inches*)	Length of Follow-up (*Years*)	Discrepancy at Time of Follow-up (*Inches*)
Males				
Femur, tibia, and fibula (Case 1)	11	1¼	4	¾ (Deformity)
Femur, tibia, and fibula (Case 4)	14	1¾	3	¾ (Deformity)
Femur, tibia, and fibula	14	3	2	1½
Femur	12	1¾	2	1¼
Tibia and fibula	13	2	1	¾
Femur, tibia, and fibula	13	2½	1	1½
Femur, tibia, and fibula	13	1½	1	1½
Tibia and fibula	12	2	1	1¾
Femur, tibia, and fibula	13	2½	1	½
Femur, tibia, and fibula	15	2½	1	2½
Femur, tibia, and fibula	12	4	1	3¼
Tibia and fibula	13	1	1	½
Tibia and fibula	13	1½	1	¾
Femur, tibia, and fibula (Case 2)	11	1¾	1	½ (Deformity)
Tibia and fibula (Case 3)	11	1¼	1	1 (Deformity)
Females				
Femur, tibia, and fibula	13	1	8	1
Femur, tibia, and fibula	10	2¾	7	2
Femur, tibia, and fibula	12	2	7	½
Femur, tibia, and fibula	13	2	7	Equal
Femur, tibia, and fibula	13	2	6	1½
Tibia and fibula	12	2	4	2
Femur, tibia, and fibula	10	2⅜	4	3¼
Femur, tibia, and fibula	12	2	3	1¼
Femur	11	3½	3	2¼
Femur	10	2	3	⅜
Femur	10	1¾	3	½
Femur	10	1¼	3	¾
Femur, tibia, and fibula	12	1½	1	1⅜
Femur	12	1½	1	1¼
Femur, tibia, and fibula	14	1⅞	1	1
Femur, tibia, and fibula	13	1	1	1
Tibia and fibula	10	1¼	1	1¼
Tibia and fibula	10	1	1	¾
Femur, tibia, and fibula	11	2¼	1	2
Tibia and fibula	12	1¼	1	1
Femur, tibia, and fibula	11	2¼	1	1⅛

POSTOPERATIVE DEFORMITIES

Deformities attributable to surgical epiphyseal arrest are apparently not common. Compere reported more than 100 cases of epiphyseodesis of the lower extremity, without complications. In a review of sixty-six cases of surgical arrest in the lower extremity, Steindler found no deformities attributable to the epiphyseal fusion. Campbell mentioned the possibility of asymmetrical fusion with subsequent deformity (genu varum, genu valgum, or genu recurvatum). He had observed two cases of slight genu valgum following arrest, in which the deformity was not enough to warrant surgical correction. In another case, definite genu recurvatum developed three years after arrest by the Phemister method. Wilson and Thompson stated that, although late deformities had not been reported, they had observed three cases in which operation was performed according to the Phemister technique, and in which there developed disalignment at the knee sufficient to warrant operative correction. Straub, Thompson, and Wilson, in a recent study of their cases of epiphyseal arrest, found that deformities resulting from unequal arrest constitute a serious hazard. Deformities usually developed within a year after operation.

Of eighty-nine patients upon whom epiphyseodesis was done, fifteen showed deformities. Eight deformities were severe enough to warrant corrective operation. In seven of these fifteen cases the type of deformity was genu valgum, in six it was genu varum, in one it was varus of the lower femoral segment and valgus of the upper tibial segment, and in one case the deformity was not recorded.

Campbell explained the development of genu valgum on the basis of technical error, since the approach to the lateral surface of the tibial epiphysis is more difficult than the approach to the medial surface, and the tendency is for the surgeon to arrest the anterolateral part of the epiphysis rather than the lateral portion. In the case of genu recurvatum following arrest, which he mentioned, only the anterior part of the epiphysis of the tibia was arrested and the posterior part continued to grow, resulting in an anterior tilting of the articular surface of the tibia. Straub, Thompson, and Wilson believed that the deformities they noted resulted from faulty technique, especially in the preparation and placing of the bone grafts. In their opinion, contributory factors in the production of deformities may be the lack of plaster-of-Paris immobilization and too early weight-bearing.

REVIEW OF CASES

This report includes all surgical epiphyseal arrests performed from June 1, 1933, to December 31, 1943, inclusive, which afforded a postoperative check-up of at least one year prior to December 31, 1944. During this period of ten years and seven months, a total of thirty-six patients underwent operation for epiphyseal arrest for inequalities of limb length. The etiological factors responsible for discrepancies in the length of the lower extremities in this series (Table I) seem to coincide with those observed by other writers. Tabulations were made of the sex, epiphyses arrested, age at time of operation, amount of discrepancy in length of limbs at the time of operation and at the time of follow-up, and length of follow-up period (Table II). It is obvious that in some instances equalization did not occur, yet the procedure arrested progressive discrepancy. Deformities following arrest

FIG. 1-A FIG. 1-B FIG. 1-C

Lower extremities in Case 1.

Fig. 1-A: Before arrest. Note apparently equal length; there was compensatory tilting of the pelvis, which is not shown.

Fig. 1-B: One year and six months after arrest. Note increasing valgus deformity of the left knee.

Fig. 1-C: Four years after arrest.

November 1940
FIG. 1-D

June 1944
FIG. 1-E

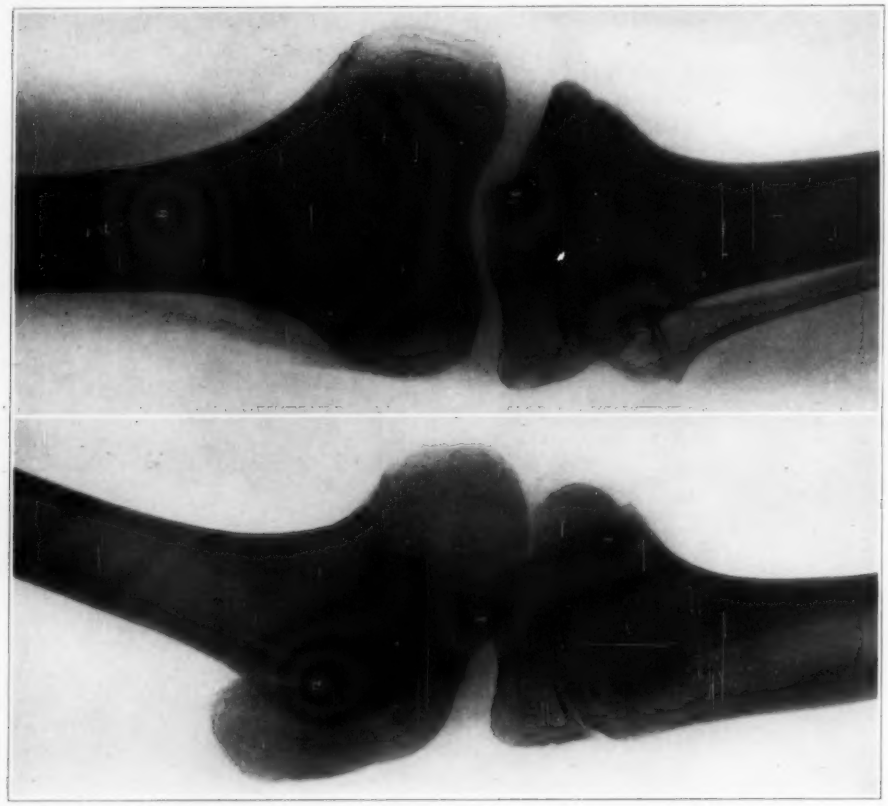
Anteroposterior roentgenograms of the left knee. Compare the deformities of the bone with those shown in Figs. 1-A and 1-C. In Fig. 1-E only the lateral portion of the tibial epiphysis has fused; the medial part is apparently growing.

and directly attributable to the procedure occurred only in males in this series; this fact, of course, is of no significance in determining the outcome of the operation.

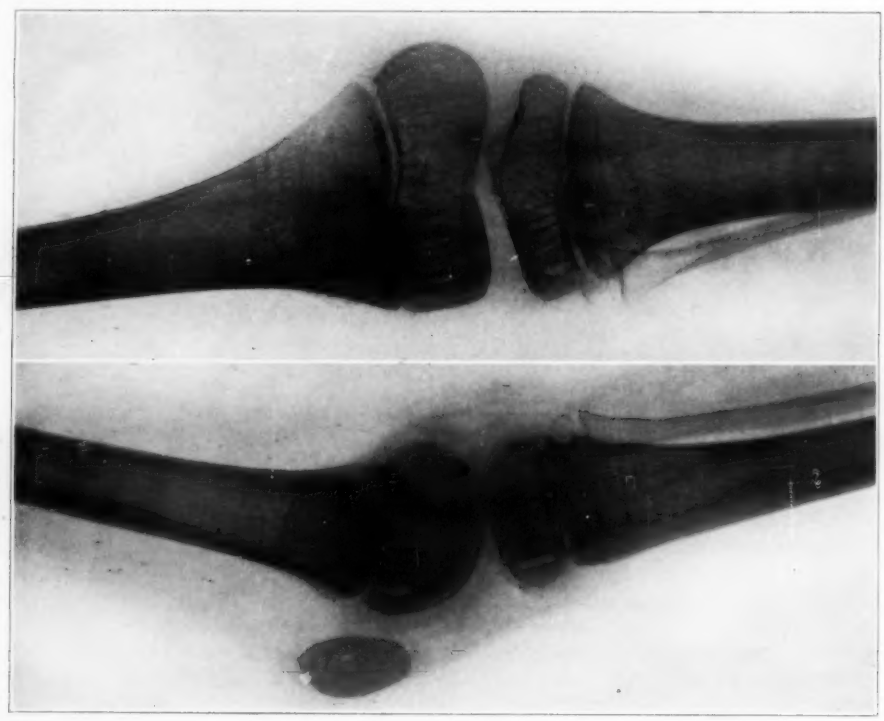
The technique of Phemister was followed in all cases, with slight modifications, depending on the individual surgeon performing the operation.

Of the thirty-six patients, four showed noticeable deformity in from two months to two and one-half years after arrest had been attempted. In Cases 1, 2, and 3, corrective surgical procedures were performed after the deformity occurred. In Cases 2 and 3, rearrest of the epiphyses was performed at the time of the corrective operation. In Case 1 the deformity recurred after correction, and probably rearrest should also have been done; the patient will need further surgical treatment. In Case 4 the authors contemplate corrective osteotomy, if the deformity increases.

CASE 1. The clinical diagnosis was atrophy and shortening of the right lower extremity, following poliomyelitis. The lower extremities of the patient before, and at two periods after, arrest are shown in Figures 1-A, 1-B, and 1-C; roentgenograms of the left knee are shown in Figures 1-D and 1-E. At the first examination in 1931, the rikht lower extremity was one-quarter inch (0.6 centimeter) shorter than the left. In April 1940, it was one and one-quarter inches (3.2 centimeters) shorter than the left (Fig. 1-A). In September of the same year, when the patient was eleven years of age, arrest of the left lower femoral epiphysis was performed. One month later, the left upper tibial epiphysis was arrested. Three months afterward there was noticeable valgus deformity of the left knee, and the right lower extremity was one and one-quarter inches shorter than the left. In June 1941, the upper epiphysis of the left fibula



November 1944



June 1943

FIG. 2-B

FIG. 2-A

Lateral and anteroposterior roentgenograms of the right knee. Note arrest at medial aspect of tibial epiphysis, and apparently growing lateral portion.

was arrested. In February 1942, because of the deformity (Fig. 1-B), wedge osteotomy of the lower end of the left femur was done to correct the valgus of the knee. When examined five months later, the limb was straight. The valgus had recurred when the patient was seen again in March 1944 (Fig. 1-C). This was progressive and in June 1944 (Fig. 1-E), a valgus of the left knee amounting to 25 degrees, with a shortening of the right lower extremity amounting to three-quarters of an inch (1.9 centimeters), was recorded. A note was made that further corrective surgical treatment was contemplated.

FIG. 2-C FIG. 2-D

Lower extremities in Case 2.

Fig. 2-C: Before arrest.

Fig. 2-D: One year and five months after arrest. Note varus deformity of right knee.

CASE 2. The clinical diagnosis was paralysis and atrophy of the left lower extremity, following poliomyelitis at two years of age. The lower extremities of the patient before and after arrest are shown in Figures 2-C and 2-D; roentgenograms of the right knee are shown in Figures 2-A and 2-B. The patient had been observed from time to time since 1934, one year after the acute attack of poliomyelitis. At the initial examination in November 1934, there was shortening of the left lower extremity, amounting to one and one-eighth inches (2.9 centimeters). During the following seven years there was a slow, progressive shortening, and in 1943 the left lower extremity was one and three-quarters inches (4.4 centimeters) shorter than the right (Fig. 2-C). In September 1943, when the patient was eleven years of age, arrest of the right lower femoral and of the upper tibial and fibular epiphyses was done. Two months afterward there was beginning varus deformity of the right knee, with shortening of the left lower extremity of one-half inch (1.3 centimeters). This, of course, was an inaccurate measurement, due to the deformity. When the patient was seen one year and five months after arrest, the deformity had increased (Fig. 2-D) and corrective osteotomy of the right tibia was performed.

CASE 3. The clinical diagnosis was paralysis and atrophy of the left lower extremity, following poliomyelitis at two years of age. When the patient was seen in 1933, one year after the acute attack of poliomyelitis, the limbs were of equal length. Four years later the left lower extremity was three-quarters of an inch (1.9 centimeters) shorter than the right. In June 1941, when the patient was eleven years of age (Fig. 3-A), there was shortening of one and one-quarter inches (3.2 centimeters). The right upper tibial and fibular epiphyses were arrested at that time. One year later the discrepancy had decreased by one-quarter inch (0.6 centimeter). In May 1943, valgus deformity was present (Fig. 3-B). One month later rearrest was done, and in January 1944, wedge osteotomy of the upper end of the right tibia was done for correction of the deformity.

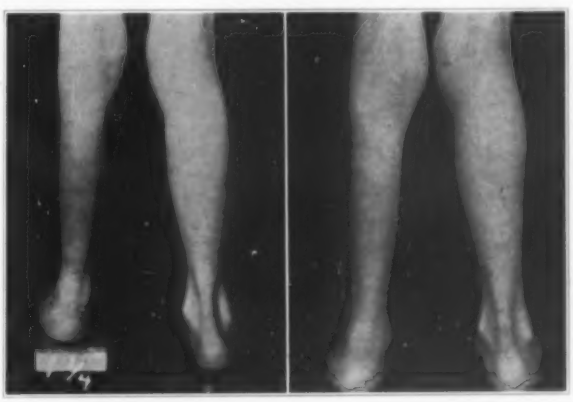


FIG. 3-A FIG. 3-B

Lower extremities in Case 3.

Fig. 3-A: Before arrest.

Fig. 3-B: One year and eleven months after arrest. Note the valgus deformity on the right and the apparent equalization of limb lengths.

CASE 4. The clinical diagnosis was paralysis and atrophy of the right lower extremity, following poliomyelitis at three years of age. This patient was first seen in January 1941, at which time there was shortening of the right lower extremity, amounting to about one and one-quarter inches. One year later the shortening was

one and one-eighth inches (2.9 centimeters). In July 1941, measurements showed shortening of one and three-quarters inches (4.4 centimeters), and, as the patient was fourteen years of age, arrest of the left lower extremity was done in the lower femoral and the upper tibial and fibular epiphyses. The patient showed an excellent progressive equalization until his last visit in January 1944, when, for the first time, the knee showed a valgus deviation of 15 degrees and the right lower extremity was three-quarters of an inch (1.9 centimeters) shorter than the left. If the deformity increases, which is doubtful since the patient has reached his seventeenth year and normally should have little more epiphyseal growth, a corrective operation will be done.

COMMENT

The authors believe that complications are few following epiphyseal arrest by the Phemister method, when it is performed under adequate conditions and by competent surgeons. Postoperative wound infections are rare, since the incisions are relatively small and the operating time is short. If surgical asepsis is practised, there should be no subsequent suppuration.

Wilson and Thompson concluded that epiphyseal arrest has the advantage over the other operative methods (sympathectomy, limb lengthening, and limb shortening) of being a relatively minor surgical procedure. Careful calculation is necessary to determine the age at which the operation should be performed, and which epiphysis should be subjected to fusion. When a gross discrepancy of length is to be overcome, the operation must be performed early. Complete fusion must be obtained in order to avoid any danger of later deformity due to asymmetrical growth. In their opinion, in which the authors concur, this method offers the simplest and safest means of equalizing limb length. Unfortunately, its application is limited to the period of bone growth.

SUMMARY

In four of thirty-six cases of surgical epiphyseal fusion (carried out according to the technique of Phemister), deformities followed and were directly attributable to the operation. These deformities resulted from incomplete and asymmetrical arrest of epiphyseal growth and often necessitated further surgical intervention.

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LAG-SCREW FIXATION IN FRACTURES OF THE TIBIAL TUBEROSITY

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There are several reasons why fractures of the tibial plateau frequently result in disability. Among these is faulty reduction and inadequate fixation during the period of healing. An excellent reduction may be lost while the limb is fixed in a cast. Genu varum or genu valgum, resulting from incomplete reduction and inadequate fixation of the fracture, creates a faulty weight-bearing line through the knee joint. Open reduction makes possible accurate replacement of fragments.

Five years ago the author began to use a vitallium lag screw of the Lippmann type in order to maintain reduction of these fractures. The screw prevents outward displacement of fragments. At the same time it may be so directed as to counteract any tendency to depression of the plateau, an advantage which the through-and-through bolt does not possess.

The ability of the corkscrew or lag screw to hold firmly in cancellous bone has been demonstrated by both Lippmann and Henderson in fractures of the femoral neck. Trabecular bone requires the large surface grip of the corkscrew. An ordinary vitallium wood screw is not sufficient. The lock washers of the through-and-through bolt are, in the author's opinion, too small to hold the fragments in three planes. In addition, the line of the bolt must be nearly in the coronal plane to ensure protrusion of the end for the application of the lock washer and nut. The author feels that this coronal position of the through-and-through bolt tends to lose the desired elevating force on the fragments, and affords only an impacting force.

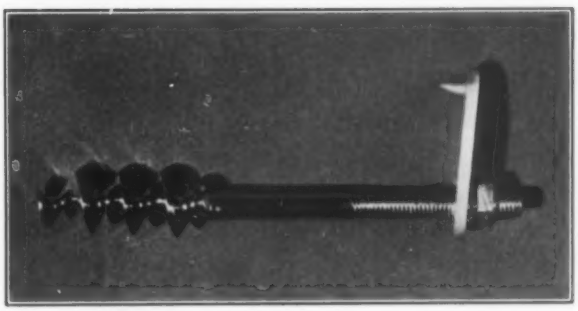

FIG. 1

Lippman screw, showing lock washer with spur.

Insertion of the screw into the largest depressed fragment is done gently with the ordinary hand drill, so that the fragment will not be broken. The screw grasps a large amount of intact cancellous bone on the side opposite the fracture. It is inserted through the largest fragment at the angle of maximum efficiency. This is determined by roentgenographic study and inspection at operation, at which time all fragments are reduced and held in the position of complete reduction by a blunt instrument. The screw is three and three-eighths inches in length, and the wide-thread, or corkscrew, element is three-eighths of an inch in diameter. These dimensions have been found to be adequate after study and measurement of many tibiae. The squared shank makes for ease of insertion with drills of different types, and is fitted with a large oval lock washer with a square hole, which cannot turn on the shank. The washer is fitted on the shank in such a position that the spur will be driven into intact bone, thereby locking the fractured fragments in three places. Next, the nut is tightened firmly onto the washer, thus giving fixation in three planes,—the sagittal, coronal, and lateral. The horizontal impaction is the most important, as it prevents possible separation of the fragments by rotary force, and produces transverse closure of the fracture line. The free end of the screw under the skin has not caused complications or discomfort.

Four cases have been selected, demonstrating different types of lesions and fixation with the vitallium lag screw.

CASE 1 is that of a simple comminuted fracture of the tibial condyle. The reduction and insertion of the screw was accomplished through a very small incision directly over the fracture. In contrast to

FIG. 2-A

FIG. 2-B

FIG. 2-C

FIG. 2-D

Case 1. Simple comminuted fracture of the lateral tibial condyle, not requiring removal of lateral cartilage.

Figs. 2-A and 2-B: Before reduction.

Figs. 2-C and 2-D: After reduction and insertion of screw.

what is usually required, it was not necessary in this case to make an incision into the knee joint proper. A minimum of upward impaction was needed; hence the screw was directed slightly upward and extended across the tibia, well past the fracture line, to grasp good bone. The patient was treated four years ago and has been asymptomatic during this time. The patient refused to have the screw removed.

CASE 2 presented a fracture of the posteromedial portion of the tibial plateau. It was necessary to start the screw from a slightly posterior angle in order to re-establish the horizontal plane. This screw was directed upward slightly to prevent subsequent depression while healing, in order to effect the transverse impaction and to overcome the rotary force. One year after removal of the screw, excellent painless stability was present, and no arthritis had developed in the joints. During this period the patient was on military duty, which necessitated a great deal of walking and required a painless, stable knee.

CASE 3 was one of extensive comminution and avulsion of the tibial spine, which had caused the knee to be locked in flexion. It was necessary to open the knee joint, exposing the entire fracture. The medial cartilage was badly torn and had to be removed. The tibial spine was replaced in its normal position. The plateau fracture was reduced with a periosteal elevator, and held in place by direct pressure and abduction of the leg. The screw was inserted through the largest fragment to the opposite side of the tibia in order to draw the fragments together. The nut was tightened over the lock washer after the spur had been forced into intact bone.

CASE 4 was one of compound fracture of the lateral tibial plateau, which opened widely into the knee joint on the lateral side. The patient was first seen eighteen hours after the fracture had occurred. After débridement, including the removal of the lateral cartilage, of which the anterior three fourths was hanging free from the wound, it was evident that an accurate reduction and maintenance of the large tibial plateau fragment must be carried out, if any function of the joint was to be retained. The fragment would not stay in place without skeletal fixation. Hence, the screw was inserted and directed downward, since the remaining portion of the lateral collateral ligament kept drawing it out of its proper position. The lock washer was turned so as to lock the spur in the bone anteriorly, in order to prevent depression of the tibial plateau during the early absorptive period of bony union. The wound was left open after suture of the synovial membrane. Penicillin was used in the joint and consequently no infection resulted. The screw was removed in twelve weeks. Only one dressing was performed in eight weeks, when the cast was changed.

All patients were placed in casts from the upper thigh to the toes, with the knee in 25 degrees of flexion. The patient with compound fracture was placed in a hip spica cast, because he had also a compound fracture at the juncture of the pubic and ischial spine.

Accurate reduction and internal fixation are demonstrated in these four cases. They include the simple fracture, the comminuted fracture which involves most of the joint with the tibial spine, and the severe compound fracture with avulsion of the tibial condyle. Damage to the meniscus is often present, requiring its removal at the time of the reduction and internal fixation. In those instances in which the ligamentous tear is not too severe and the cartilage is not torn, however, the cartilage can be preserved, and has been demonstrated by roentgenogram to be present and intact a year after solid bony union has taken place. Accurate reduction and healing without deformity of the knee produce a normal weight-bearing line, and the secondary hypertrophic post-traumatic arthritic changes that invariably follow the malunion of condylar fractures are either prevented or certainly reduced in amount.

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ALLERGY OF JOINTS

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The most common and the best-known type of allergic involvement of the joints is that seen in serum sickness and in drug allergy. The manifestations include stiffness, swelling, redness, and pain in the joints. There is evidence of local oedema, resulting in exudation of fluid. The reaction usually lasts for only a short time.

As early as 1895, Osler brought out the fact that a certain percentage of patients suffering from Henoch's purpura present transient recurrent articular manifestations. These patients show a variable combination of the following symptoms: (1) skin findings, such as purpura, urticaria, and angioneurotic oedema; (2) abdominal symptoms (colic, diarrhoea, and gastro-intestinal hemorrhages); and (3) involvement of the joints, due to periarticular and intra-articular oedema and effusion. Osler reported eleven instances of Henoch's purpura; five of these patients had articular symptoms. In one, the swollen painful joints and purpura followed the injection of iodoform into the hip joint; this could have been due to a sensitivity to the drug. Osler collected fifty cases of Henoch's purpura from the literature, thirty-two of which presented some form of "arthritis", due to an effusion in the tendon sheaths along the joints. In 1914, he cited several additional cases of the same condition, and mentioned the possibility that this condition might be due to protein sensitivity.

Alexander and Eyermann reported four cases of Henoch's purpura. All of their patients had gastro-intestinal and abdominal symptoms; one had urticaria, three had purpura, and two had arthritic manifestations. All of the patients showed unmistakable clinical evidence of food sensitivity. In 1929, the same authors presented six more cases of clinical food sensitivity, which produced the various manifestations of Henoch's purpura. These reports on Henoch's purpura are cited here because the recurrent joint manifestations are a prominent symptom in this condition, and, furthermore, because there is evidence that allergy to foods plays an important role in their production.

There are in the literature, however, other references to recurrent, transient articular involvement, occurring without serum sickness, drug allergy, or Henoch's purpura, which

are caused by allergy to food. Among these may be mentioned the reports by Bolton, Bezançon and his associates, Turnbull, Adelsberger and Munter, Lewin and Taub, Service, and Berger. For the most part, they include symptoms of intermittent swelling and pain in the joints, resulting from the ingestion of certain foods, particularly fish, nuts, and eggs. Sometimes the condition was associated with other allergic manifestations,—usually urticaria and angioneurotic oedema.

The purpose of this paper is to call attention again to the possibility that intermittent swelling of various joints in the body may occasionally be of allergic origin.

CASE REPORTS

CASE 1. I. D., a female, aged forty, gave a history of paroxysms of excruciating pain in the back of the neck, radiating down to the right shoulder and the right arm. This condition had been present, off and on, for five months. Accompanying the pain, there was some swelling of the right shoulder and the right upper arm. The patient found it difficult to turn her head in either direction. During the attack, motion and physical activity always aggravated the symptoms. At other times the pain would come on suddenly, without apparent provocation, even waking her in the middle of the night. Because of the frequent nocturnal occurrence of the pain and consequent loss of sleep, the patient became quite irritable and lost a great deal of weight. Several months after the onset of the pain, because symptomatic treatment did not give relief, she was hospitalized for a complete investigation. At this time the physical examination was entirely negative, except for some tenderness over the entire trapezius and deltoid muscles, and over the spinous processes of the mid-cervical and lower cervical vertebrae. Mild muscle spasm could be palpated over the right shoulder and arm. Roentgenograms of the entire cervical and thoracic spine were negative. The urine was negative. The blood count, sedimentation rate, blood chemistry, and serology were normal. The eosinophil count was 9 per cent. The patient was studied by an internist, an orthopaedic surgeon, and a neuropsychiatrist. Because of marked emotional manifestations, without any positive objective data, she was discharged from the hospital with a diagnosis of functional neurosis.

The condition had become increasingly worse when the patient was seen on November 3, 1943. In addition to the history stated above, she also complained of intermittent swelling and pain of the middle finger of the right hand. This joint presented a fusiform swelling, without marked redness or heat. The swelling was accompanied by definite limitation of motion. Roentgenograms showed no pathological changes in the joint. All laboratory tests were negative.

The patient had been seen on previous occasions. She reported in July 1930, complaining of indefinite gastric symptoms and occasional pain in the region of the thoracic vertebrae. There was local tenderness over the thoracic spinous processes. The pain was aggravated by motion. Two years later she was seen at home because of severe and intractable generalized urticaria, which covered practically the entire body. On another occasion a marked contact dermatitis developed after she had worn a black chiffon-taffeta dress. She found repeatedly that the ingestion of chili sauce or tomatoes produced generalized hives.

The patient was seen again in April 1938. Following a course of emmenin, urticaria and marked swelling of the right knee and right ankle developed. The emmenin was discontinued and the joint condition disappeared, only to return with resumption of treatment. There was no family history of allergy, and no history of associated allergic manifestations.

Because of the past history, it seemed possible that the patient's present intermittent condition, involving the cervical vertebrae and the joints of the middle finger of the right hand, might be allergic. Positive skin reactions were obtained to many foods. She was found to be sensitive clinically to tomatoes, chili sauce, fish, and grapes, although no skin reaction could be obtained from the grapes. On several occasions the patient experienced joint symptoms after eating grapes or drinking grape wine. Withdrawing these foods from her diet brought about complete disappearance of her symptoms.

CASE 2. R. H., a male, aged thirty-seven, was seen in April 1941, when he complained of intermittent pain and swelling of the right great toe. This was occasionally associated with swelling and pain of the right ankle. The joints were not tender. The skin was tense and burning and, after the swelling had disappeared, the skin scaled. At times the swelling had been so marked that the patient could not put on his shoe. He stated that he had previously had a similar condition in his right knee, and at that time he had found it difficult to drive his car. The patient received treatment for arthritis and was confined to bed for a period of six weeks. Arch supports and other orthopaedic treatment did not give relief. The patient stated that he had had moderate hives two or three times, and that on at least one occasion he had had massive swelling of one eye. There was a family history of asthma.

The physical examination was entirely negative. No involvement of the ankles, toes, or any of the other joints was evident. Several weeks later, however, there was marked swelling of the great toe of the left foot. There was no redness and only slight tenderness over the affected joint. The skin was tense and drawn. The patient had extreme pain on motion and had spent several sleepless nights. Roentgenograms of the involved joint showed no pathological changes. The blood count, sedimentation rate, serology, and blood chemistry were normal.

Because of the history of hives and the lack of evidence of acute arthritis, it was decided to study the patient from an allergic viewpoint. Skin tests showed positive intradermal reactions to a great many foods, especially to nuts. In order to determine the specificity of these positive intradermal reactions, passive transfer tests were carried out. The test consists of transferring a small amount of the patient's serum (0.1 cubic centimeter) intradermally to the skin of a normal, non-allergic person. Each sensitized area was tested six to twelve hours later with an extract of almonds and peanuts. Both passive transfer tests were positive, indicating that the patient's serum contained skin-sensitizing antibodies (reagins) against peanuts and almonds. The patient recalled that on several occasions the ingestion of peanut butter produced generalized urticaria. Elimination of all nuts from his diet gave complete relief from the symptoms. The ingestion of nuts or of wheat invariably brought on a paroxysm of urticaria or some joint swelling and pain.

CASE 3. The patient was a twelve-year-old girl who was first seen in 1942, when she complained of intermittent swelling of the right ankle and the left wrist. The joints became swollen without any apparent cause and the swelling persisted for a period of several hours, or at times for several days, during which she could not move her foot or hand without severe pain. The swelling was not accompanied by fever or by increased local heat or redness. There was no history of involvement of the other joints. There was no history of growing pains, acute rheumatic fever, chorea, or any other rheumatic infection. The tonsils had been enucleated when the patient was five years old. The patient had had several attacks of urticaria some years before. She had had an intolerance for eggs for many years; the ingestion of even a small quantity of egg would produce generalized urticaria. There was no family history of allergy.

At the time of the first examination, there appeared to be no articular involvement. The physical examination was entirely negative, except for a systolic murmur which was not transmitted. An electrocardiogram and a roentgenogram of the heart were normal. The sedimentation rate was normal. The blood examination showed an eosinophilia of 10 per cent.

The absence of fever and of signs of local inflammation, the normal sedimentation rate, normal roentgenogram, and positive allergic history suggested the possibility that this might be a case of angioneurotic oedema, which from time to time involved various joints. The patient showed a marked positive reaction by direct skin test to eggs and to several other foods. A small quantity of egg albumen by mouth gave rise to urticaria. On only one occasion, however, did the ingestion of egg cause swelling of the right ankle. The patient was placed on a completely egg-free diet and has been entirely free of joint symptoms for the past two years.

CASE 4. J. C., a male physician, aged sixty-five, was present at a medical meeting where the subject of allergy was being presented. After the meeting he cited his own experience, stating that he had had an allergy for a great many years. The patient had a family history of allergy. Paroxysmal attacks of blindness in one eye and intermittent swelling of several joints of his fingers occurred after the ingestion of fish. The joint or joints would become swollen, tender, and painful, and the condition would last from a few hours to a few days. The physical examination was otherwise negative. He stated that examination of the eyegrounds showed oedema of the macula in the affected eye during a paroxysm. The patient could always induce the swelling of his fingers by eating fish. Absolute avoidance of all fish and fish products gave complete relief.

COMMENT

Allergic arthropathies may be classified as follows:

The first group includes those instances of long-standing, chronic infectious arthritis which are thought to be due to bacterial allergy. Little is known about the allergic nature of this group and it is not included in this presentation.

In the second category is articular swelling resulting from sensitivity to a foreign serum or to a drug. This condition is usually transitory and is easily recognized as allergic, because it is a part of a generalized reaction to serum or drug.

The third group includes intermittent hydrarthrosis, which is a massive recurrent swelling of a joint, usually the knee. It is found more frequently in women than in men, and is accompanied by effusion of fluid into the joint.

In the fourth group are cases of Henoch's purpura associated with articular swelling and pain which, in some instances at least, might be due to allergy.

The fifth group comprises cases of acute transient paroxysmal articular involvement of joints, characterized by pain, swelling, and limitation of motion. Clinically, the cases simulate subacute arthritis, except for the absence of elevation of temperature, leukocytosis, increased sedimentation rate, and positive roentgenographic findings. This condition is transitory and recurrent and is associated with other allergic conditions, such as migraine, urticaria, angioneurotic oedema, asthma, and hay fever. Eosinophilia may be present. Positive skin tests may be elicited. The allergic nature of the condition is proved by clinical trial.

It is with this last type of joint involvement that this paper is concerned. The patient complains of excruciating pain which is migratory, sometimes involving the joints of the fingers, at other times involving the vertebral articulations or other joints of the body. At the time of the examination, nothing may be found and the patient may be labeled psychoneurotic, as in Case 1. On the other hand, the diagnosis of subacute or even of acute rheumatic fever may be made, and the patient may be confined to bed needlessly for a long period of time.

The mechanism of production of symptoms is probably the same as that in urticaria or angioneurotic oedema; the shock tissue is the synovial membrane of the joint, instead of the skin. Considerable, but transient, peri-articular oedema may occur, and at times there may even be a small amount of transudate into the joint cavity. This fluid may or may not be rich in eosinophils. The reaction, however, is reversible. The allergy is due to sensitivity to foods, and absolute elimination of these foods may result in complete relief.

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DEVELOPMENT OF SQUAMOUS-CELL CARCINOMATA IN THE SINUS TRACTS OF CHRONIC OSTEOMYELITIS

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Malignant degeneration of the skin which lines sinus tracts is not always readily recognized as a complication of chronic osteomyelitis. The carcinomatous lesions are in some instances large, cauliflower-like epitheliomata extruding from the sinuses; however, the more insidious variety, often unsuspected until the development of metastases, exists deep in the epithelialized cavities. Stewart, Obermayer, and Woolhandler reported a case in which skin metastases occurred, following the amputation of a thumb for chronic osteomyelitis. The pathologist's examination of the amputated phalanx then revealed the primary epithelioma.

Early recognition of malignant changes is often obscured by the primary pyogenic process. Most lesions exist for some time before their true nature is discovered. The purpose of the present paper is to point out the clinical and roentgenographic signs of this disease.

Henderson and Swart reported on five patients with malignant lesions among 2,396 cases of chronic osteomyelitis. Benedict found twelve such cases among 2,400 patients afflicted with chronic osteomyelitis. The epithelialization of draining sinuses in cancellous bone is well recognized. Milgram claims this to be one cause of persistent drainage.

Bereston and Ney, in reviewing the literature, found that malignant changes most often develop in males between the ages of forty and sixty years, who have had draining sinuses of from twenty to fifty years' duration. The tibia, the femur, and the bones of the foot are most often involved.

Hellner emphasized that increased pain, increased foul discharge, and bleeding from a sinus are indicative of malignant changes in chronic osteomyelitis. A pathological fracture in the infected area should also arouse suspicion. The discharge of small, white, cheesy masses, composed of desquamated, keratinized epithelium, is sound evidence that the sinus is well epithelialized.

Roentgenographic studies are not characteristic, so long as the malignant lesion is limited to the skin lining the sinus. Roentgenograms of the two cases to be presented, however, show many small areas of rarefaction in the sclerotic bone surrounding the sinuses. Hellner described similar roentgenograms in his cases of chronic osteomyelitis complicated by squamous-cell carcinoma, and he thought this to be characteristic of malignant invasion of the bone.

The positive diagnosis is made by performing a biopsy of material from the sinus tract. Curettage is not sufficient, since the lesion may be missed. Furthermore, when the material for biopsy is obtained by a superficial curettage, the pathologist may be unable to distinguish between a carcinoma and inflammatory changes. Therefore, the biopsy is best done in the operating room with the lesion fully exposed; several sections, thick enough to include the subcutaneous tissue, should be excised. Quick frozen sections are of little value, since a positive diagnosis usually can be made only when the lesion is grossly an obvious carcinoma.

Most authors report that the carcinomata associated with draining sinuses are well-differentiated, squamous-cell epitheliomata. That they show little tendency to metastasize has been pointed out by Bereston and Ney, who found only four cases in the literature and added two cases of their own in which visceral metastases were present. Metastasis to the lymph nodes may occur, but in most instances enlarged nodes are inflammatory and subside after amputation.

FIG. 1-A

FIG. 1-B

Case 1, F. T. Anteroposterior and lateral roentgenograms of lower third of femur, demonstrating extensive destruction of the shaft and small irregular areas of rarefaction in cortex surrounding the large abscess cavity.

Amputation is usually the best method of treatment. Because of the existing infection, it is logical to perform a guillotine amputation as close to the involved area as may be done with safety. If enlarged lymph nodes are present and do not subside after the amputation, they should be excised, since they may contain metastatic carcinoma. Roentgenotherapy may then be initiated. The prognosis following amputation is good, since there are few early metastatic lesions.

CASE REPORTS

CASE 1. F. T., a white laborer, sixty-seven years of age, entered Stanford University Hospitals in February 1939, complaining of increased pain, foul discharge, and bleeding from the sinuses in his right thigh of eight months' duration. For sixty years he had had chronic osteomyelitis of the femur. Examination revealed a pathological fracture. On the medial and lateral sides of the middle third of the thigh were foul, discharging, epithelialized sinuses, which extended from large cavities deep within the bone. On the medial side, an abscess of the soft tissue extended up the thigh. Malignant changes were not suspected. A roentgenogram of the femur demonstrated an extensive osteomyelitic process, involving the distal half of the bone (Figs. 1-A and 1-B). Multiple small areas of destruction were noted in the sclerotic bone surrounding a large cavity in the femur. Several small sequestra were identified.

A pathological fracture, combined with the extensive destruction, necessitated drastic treatment. Accordingly, a guillotine amputation was done above the lesion. The stump healed well, except for a firm mass of what appeared to be granulation tissue; on pressure, this exuded caseous material. The mass was excised, and on microscopic examination it was found to be a squamous-cell carcinoma of a well-differentiated variety. Further examination of tissue from the sinus tracts of the amputated leg

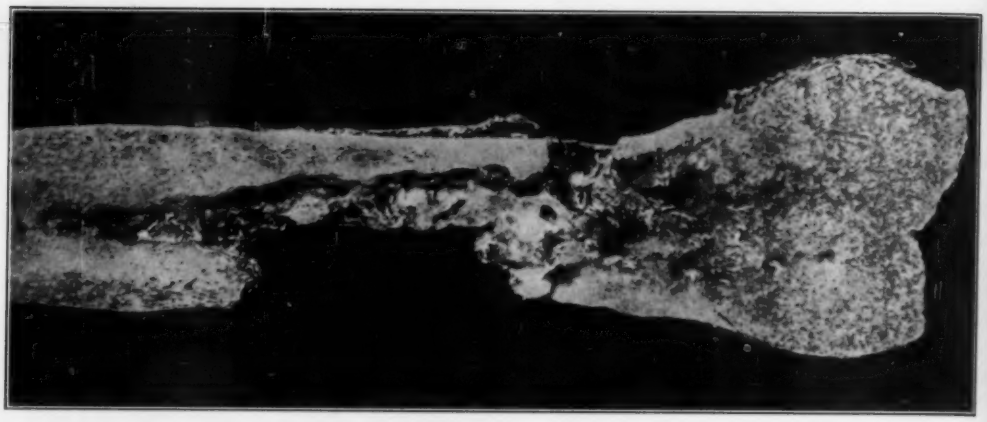

Fig. 2-C

Fig. 2-B

Fig. 2-A

Case 2, H. T. Anteroposterior and lateral roentgenograms of lower third of femur. Small areas of rarefaction are present in the anterior bone cortex. Lateral section of femur demonstrates the anterior bone cortex thus destroyed.

FIG. 2-A

FIG. 2-B

FIG. 2-C

Case 2, H. T. Anteroposterior and lateral roentgenograms of lower third of femur. Small areas of rarefaction are present in the sclerotic bone surrounding the large abscess cavity. Lateral section of femur demonstrating

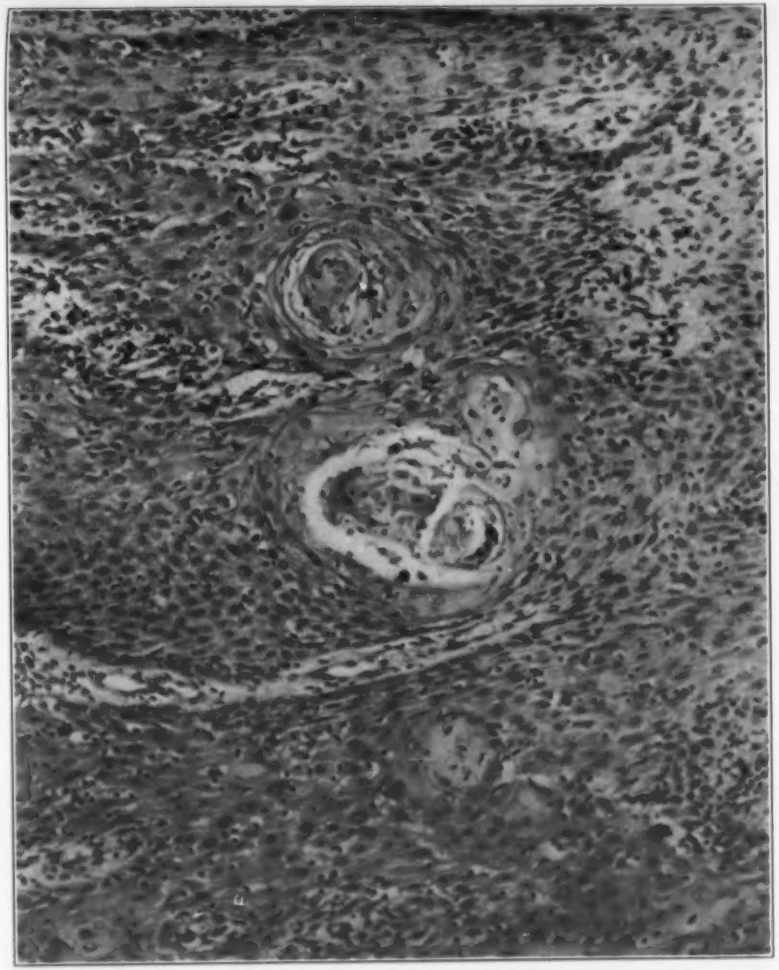

FIG. 2-D

Photomicrograph, demonstrating well-differentiated squamous-cell carcinoma.

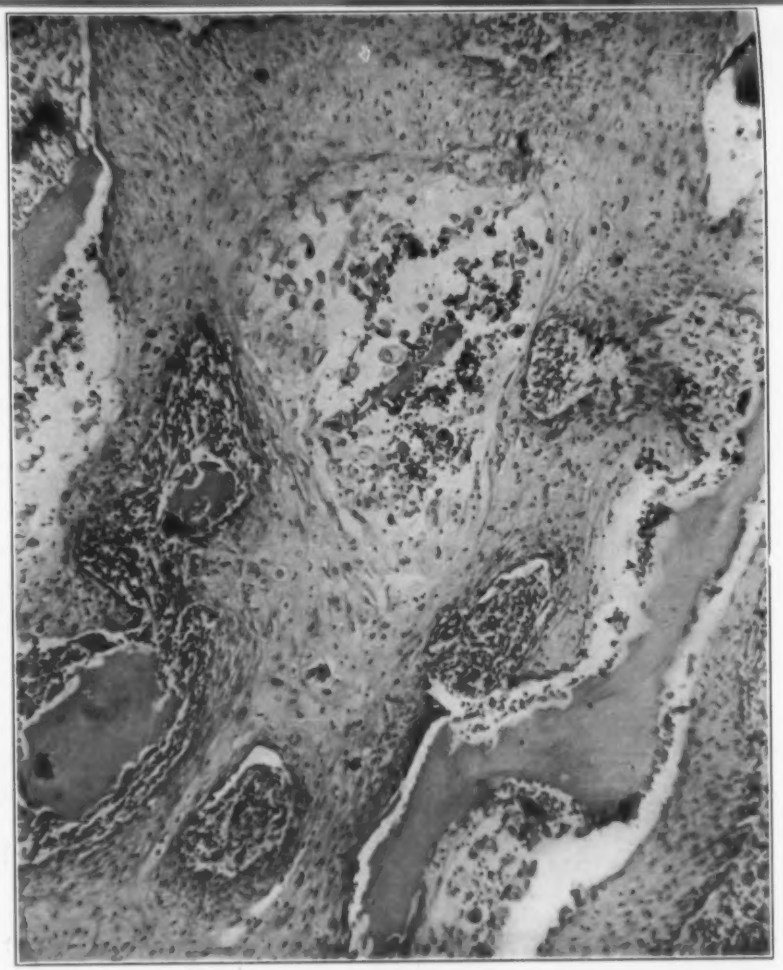

FIG. 2-E

Photomicrograph, demonstrating squamous-cell carcinoma surrounding dead bone.

disclosed the primary epithelioma. The amputation wound healed, and the patient is in good health at the present time.

Case 2. H. T., a white business man, aged fifty-three, entered Stanford University Hospitals on November 25, 1944, with a draining sinus in his left thigh, which had been present for thirty-eight years. Many operations had resulted in only sporadic improvement. The patient walked well until three months before admission to the Hospital, when pain in the thigh caused him to use a cane. Since then the pain had increased and, in spite of chemotherapy, the discharge from the sinus became profuse and foul.

On the lateral side of the middle third of the left thigh there was a sinus, six inches long and three-quarters of an inch wide, which extended deep into the thickened, irregular femur. The skin grew evenly into the ostium around all of its edges. A profuse, putrid discharge, which contained firm, grayish, irregular particles, one to two millimeters in diameter, drained from the sinus. Three discrete, smooth lymph nodes and several smaller nodes were palpable in the left inguinal region.

Roentgenograms showed a large area of destruction in the shaft of the femur. The thickened cortex around this cavity was irregular and contained many small areas of destruction. On the medial side of the femur there was an abscess cavity, containing small sequestra (Figs. 2-A and 2-B). Roentgenograms taken of the same area, in 1934, demonstrated the large cavity; however, the femur surrounding the cavity was less irregular and the multiple small areas of destruction characteristic of the patient's recent roentgenograms were not present at that time.

Because of the changes noted in the roentgenograms, the increased pain, and the foul discharge from this obviously epithelialized sinus, a malignant lesion was suspected. The sinus was curetted. Although microscopic examination of the tissue obtained showed only chronic inflammation, it still seemed possible that a carcinoma might be present deep within the sinus.

The patient was taken to the operating room where the sinus was widely incised, exposing a large cavity in the femur. This, for the most part, was lined with skin, from which projected hard, cauliflower-like masses in several places. The anterolateral cortex of the femur over the abscess cavity was found to consist of many small spicules of bone imbedded in granulation tissue and carcinomatous tissue (Fig. 2-C). The granulation tissue, skin, and papillomatous growths were covered by foul, grayish-green pus. Necrosis had occurred in small areas in some of the larger papillomatous masses. Pathological study of the tissue which had been removed demonstrated squamous-cell carcinoma of a well-differentiated variety (Figs. 2-D and 2-E).

On December 13 a guillotine amputation of the femur was performed, two and one-half inches proximal to the upper end of the cavity. Since the amputation was done close to the infected area, penicillin was administered before and after surgery. Skin traction was applied to the stump after the operation.

A plastic operation was done on the stump at a later date. The inguinal nodes decreased markedly in size. At present the patient is healthy and without evidence of metastatic lesions.

DISCUSSION

These two cases clearly illustrate several points in the diagnosis of squamous-cell carcinoma, arising from epithelialized, chronic sinuses of bone. Both patients were in the age group in which this complication is most often found. In neither patient was the correct diagnosis obvious on clinical examination. The skin at the edges of the sinuses appeared irritated from the constant drainage. Microscopic examination of the tissue first removed showed only chronic inflammation. In fact, in Case 1, an epithelioma on the unhealed amputation stump led to re-examination and the discovery of the tumor in the amputated portion. The specimen obtained by curettage in Case 2 showed no epithelioma. Thus in suspected cases it is well for the surgeon to perform a biopsy under direct vision in the operating room and to select several suitable specimens for microscopic examination.

Both patients had tolerated their osteomyelitis well for many years. Their complaints of pain and profuse foul discharge were of several months' duration only. The first patient had a pathological fracture of the femur and bleeding from the sinuses in his thigh. These findings are characteristic of carcinoma, developing in an epithelialized osteomyelitic sinus tract.

Roentgenograms of these two patients, although not diagnostic in themselves, presented a provocative finding of small areas of destruction in the sclerotic bone surrounding

the cavities, a picture which may be the result of extension of the carcinoma, as demonstrated by Figure 2-C.

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FIXATION OF THE TRANSPLANTED TIBIAL TUBERCLE *

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For many years, transplantation of the tibial tubercle has been an accepted procedure for the correction of two main pathological conditions. It has been employed, first, to take up the slack of the quadriceps apparatus in patients with spastic paralysis, following partial neurolysis of the hamstrings; and second, to correct recurrent dislocation of the patella. This operative procedure has routinely promoted good results. In the former condition, distal transplantation, under considerable tension, promotes the optimum result; whereas in the latter condition, medial transplantation with only moderate distal fixation is best.

In both conditions, transplants have proved difficult to hold, even when transfixed with screws. This is particularly true in spastic paralysis, because of the undue tension necessary to overcome inherent increased muscle tone. In the past, the long screws necessary to anchor the transplant to the posterior cortex frequently bent; or the transplanted tubercle split and pulled away from the point of fixation. Washers placed beneath the screw heads produced better results.

Good postoperative stability was not secured, however, until plates were used, which extended below the area of defect into which the tubercle was placed. This permitted anchorage of the whole transplanted area to solid tibia. By the use of a three-holed plate, which permits two screws to pass through the transplanted tibial tubercle and the distal end of the plate to be anchored by a third screw to solid tibia, such factors as wandering or pulling loose of the tibial tubercle, and bending of screws, have been eliminated.

At operation, with the incision wide open, the knee can be completely flexed passively without producing the least motion in the transplanted tubercle mass, even in patients with spastic paralysis where massive tension is present. Three screws are necessary. Two pass through the transplanted tubercle mass to prevent its rotation, as well as to hold it tightly in its new bed; the third screw is placed distally to anchor the other two screws and to prevent them from being bent by tension of the quadriceps. Figures 1-A, 1-B, 1-C, and 1-D show the gradual evolution of the present method of fixation and the rationale of the present procedure.

* Presented before the New York Academy of Medicine, Orthopaedic Section, November 17, 1944.

FIG. 1-A

FIG. 1-B

Fig. 1-A: Tibial tubercle is held in position with a single vitallium screw. Note that rotation of the tubercle has occurred and accurate maintenance of position is poor.

Fig. 1-B: Transplanted tubercle is held more satisfactorily with two vitallium screws. Here, as in Fig. 1-A, the bone which had been removed from the new defect in the tibia was replaced at the location from which the tibial tubercle had previously been removed. This is unnecessary.

FIG. 1-C

FIG. 1-D

Fig. 1-C: Tubercle was transplanted too far distally, drawing down patella and later causing residual loss of flexion of the knee joint. Note single screw through transplanted tubercle. Distal screw anchors plate to solid bone.

Fig. 1-D: Shows present method of fastening tibial tubercle with plate. Two screws pass through plate and tubercle and a distal screw is fastened in solid tibia. The plate projects beyond the transplanted tubercle.

In transplantation of the tibial tubercle for recurrent dislocation of the patella, it is extremely important not to place the tubercle too far distally, but to gain all the medial displacement possible (Figs. 2-A, 2-B, and 2-C). The fixation with a plate and three screws remains the same. Support by a cylindrical plaster cast is necessary for one week after fixation.

FIG. 2-A

FIG. 2-B

FIG. 2-C

Fig. 2-A: Area of incision is shown in inset. Illustrates dissection of soft parts, preparatory to actual operative work. Outline of incision about tibial tubercle and through medial and lateral capsule is indicated by dotted lines.

Fig. 2-B: Capsule has been incised, tibial tubercle has been turned upward, and a new defect in medial tibial surface at distal level has been created for reception of the transplanted tibial tubercle.

Fig. 2-C: Shows final transplant of tibial tubercle downward. Tubercle is maintained in transplanted position with plate, which extends downward over unbroken tibial surface. Coaptation of tubercle with defect is maintained with two screws. Stability of the whole is reinforced by distal screw, placed in solid tibia below.

BIOCHEMICAL CHANGES IN THE FRACTURE HEMATOMA

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The morphological changes in fracture repair have been studied extensively, and recently they have been completely reviewed in a series of papers by Urist and McLean. In the early stages of fracture repair, these changes at the site of fracture are similar to the repair processes in other tissues. At first there is an acute, inflammatory reaction, produced by the trauma causing the fracture. A hematoma of variable size forms at the break in the bone, and within a few days the process of repair begins, with organization of the hematoma by the ingrowth of fibroblasts and capillaries. After from seven to fifteen days, a unique change appears in the healing fracture, which distinguishes the process from repair in other parts of the body. A homogeneous material appears between the cells of the procallus. Whether the deposition of this osteoid material may be attributed to specialized fibroblasts, or whether there is actually an ingrowth of osteoblasts from the bone or the periosteum, cannot be finally determined. The formation of actual bone can occur without relation to bone or to periosteum, as Huggins demonstrated by transplanting the mucosa of the urinary bladder onto the rectus abdominis muscle of a dog. In any event, within from ten to fifteen days there is beginning calcification at the break in the bone, and new-bone formation proceeds to bridge the fracture.

Although the morphological changes which occur in fracture repair are well known, there is incomplete knowledge of the biochemistry of calcification. Robison was the first to demonstrate alkaline phosphatase in bone and cartilage which were undergoing calcification, and to stress the relationship of this enzyme to calcification. However, alkaline phosphatase has been demonstrated in organs, such as the kidney, where calcification does not normally take place. It would seem, therefore, that this enzyme system alone, without other special conditions, is not responsible for calcification. Such facts prompted Robison to postulate that there was probably a double-enzyme system involved in calcification. In the first place, there is reasonable doubt that a suitable substrate is present at the site of calcification, upon which alkaline phosphatase can act and produce an increase in the inorganic phosphate. It is also known that the glycogen concentration is high in hypertrophic cartilage cells, and that the concentration falls rapidly as calcification takes place. Gutman and Gutman have claimed that the second enzyme system postulated by Robison is phosphorylase, and that its function in calcification is in utilizing glycogen and inorganic phosphate to form some suitable phosphoric ester for alkaline phosphatase to act upon. This double-enzyme system would be responsible for raising the concentration of inorganic phosphate so that the product of Ca^{++} and $PO_4^{\equiv}$ ions exceeded 3.3 by 10^{-6}, which is the solubility product of secondary calcium phosphate at the pH of blood.

The following experiments were carried out in an attempt to correlate the relationship of the pH, the alkaline phosphatase, and the inorganic phosphate at the site of fracture before and during calcification. The liquid hematoma at the fracture site affords a convenient fluid, which can be aspirated and subjected to chemical analysis. Determinations of the pH, the alkaline phosphatase, and the inorganic phosphorus can be carried out on the hematoma fluid, and thus some idea of the biochemical changes which occur in the healing fracture can be obtained. The hematoma fluid does not give an absolute representation of the biochemical process in fracture healing. It probably reflects these changes to a certain extent, however, and should give some indication of the major changes going on during the early stages of fracture repair.

* Formerly Arthur Tracy Cabot Fellow.

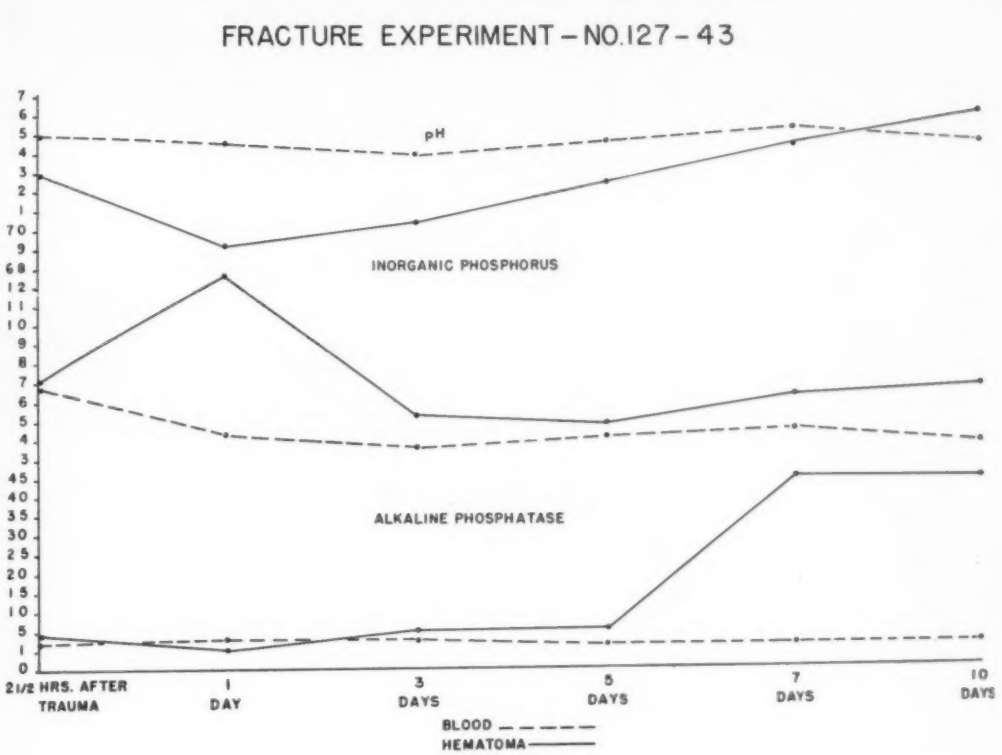

CHART I

METHODS

The operative technique consisted of aseptic exposure of the canine femur and elevation of a full-thickness spicule of bone, with resection of a portion of the vastus lateralis. The fractures produced by this method had moderate-sized hematomata, which were readily aspirated. The routine for aspiration was as follows: Two and one-half hours after the fracture had been produced, the hematoma was aspirated; and determinations of the pH, the inorganic phosphorus, and the alkaline phosphatase were carried out. The aspiration was repeated in twenty-four hours and every forty-eight hours thereafter, as long as fluid could be obtained readily. The hydrogen-ion activity was determined by the use of a microglass electrode. Inorganic-phosphorus determinations were carried out by a modification of the method of Fiske and Subbarow, in which 0.1 milliliter of fluid was used for each determination. The phosphatase was determined in Bodansky units, using 0.1 milliliter of fluid for each determination. Specimens for biopsy were taken from the fracture site at various times in order to correlate the histological findings with the biochemical results. The sections were stained by the Kossa method to demonstrate calcification. A number of fractures were produced, but a high percentage were unsuitable for this experiment, either because of infection or because of limited hematomata, which failed to give a sufficient volume of fluid for the various determinations.

RESULTS

The pH values were, in general, similar to those reported by Stirling and by Murray. Two and one-half hours after the fracture, the hematoma fluid was more acid than the venous blood; this acidity became more pronounced in twenty-four hours, the lowest pH determination being 6.9 (Table I). In the course of the next ten days, the pH gradually shifted to the alkaline side; the highest reading was 7.6.

During the first twenty-four hours after the fracture had been produced, there was a

TABLE I

COMPARATIVE DETERMINATIONS OF pH, INORGANIC PHOSPHORUS, AND ALKALINE PHOSPHATASE IN FRACTURE HEMATOMA AND IN VENOUS BLOOD

Date		pH	Inorganic Phosphorus (*Milligrams per 100 c.c.*)	Alkaline Phosphatase (*Bodansky Units*)
Fracture No. 127–43				
Aug. 10, 1943	Hematoma*	7.3	7.0	3.0
	Blood	7.5	6.9	1.0
Aug. 11, 1943	Hematoma	6.9	12.0	1.0
	Blood	7.4	4.2	2.0
Aug. 13, 1943	Hematoma	7.0	5.2	4.8
	Blood	7.4	3.5	3.0
Aug. 15, 1943	Hematoma	7.2	4.4	4.7
	Blood	7.4	3.7	2.0
Aug. 17, 1943	Hematoma	7.4	6.0	45.0
	Blood	7.5	3.6	2.2
Aug. 19, 1943	Hematoma	7.6	6.8	45.0
	Blood	7.4	3.4	2.3
	Biopsy: Definite calcification			
Fracture No. 217–43				
Sept. 17, 1943	Hematoma*	7.42	5.6	4.9
	Blood	7.51	6.4	3.2
Sept. 18, 1943	Hematoma	7.33	5.3	4.7
	Blood	7.54	3.3	6.2
Sept. 20, 1943	Hematoma	7.26	6.6	3.5
	Blood	7.48	3.9	4.3
Sept. 22, 1943	Hematoma	7.28	4.7	2.7
	Blood	7.49	4.4	2.0
Sept. 24, 1943	Hematoma	7.29	4.3	11.2
	Blood	7.52	3.9	2.8
Sept. 25, 1943	Hematoma	7.51	7.4	44.0
	Blood	7.49	4.8	1.9
	Biopsy: Questionable calcification			
Fracture No. 220–43				
Sept. 8, 1943	Hematoma*	7.18	8.3	2.1
	Blood	7.35	6.0	4.6
Sept. 9, 1943	Hematoma	7.07	18.7	3.9
	Blood	7.48	4.1	6.1
Sept. 11, 1943	Hematoma	7.19	8.6	2.6
	Blood	7.52	4.1	2.8
Sept. 13, 1943	Hematoma	7.22	4.1	3.1
	Blood	7.56	3.2	2.4
Sept. 15, 1943	Hematoma	7.29	3.2	1.0
	Blood	7.58	3.7	1.0
Sept. 17, 1943	Hematoma	7.36	4.3	6.4
	Blood	7.54	4.8	4.8
Sept. 19, 1943	Hematoma	7.32	4.0	10.6
	Blood	7.54	3.3	5.0
Sept. 22, 1943	Hematoma	7.47	5.7	51.3
	Blood	7.49	3.9	5.4
Sept. 24, 1943	Hematoma	7.53	6.3	56.3
	Blood	7.47	3.9	5.5
	Biopsy: Definite calcification			
Fracture No. 235–43				
Sept. 27, 1943	Hematoma*	7.34	6.3	2.3
	Blood	7.49	4.8	4.8
Sept. 28, 1943	Hematoma	7.25	8.5	8.3
	Blood	7.49	5.1	8.2
Sept. 30, 1943	Hematoma	7.37	5.6	5.5
	Blood	7.55	4.4	6.7
Oct. 2, 1943	Hematoma	7.42	6.0	15.0
	Blood	7.44	4.6	5.7
Oct. 4, 1943	Hematoma	7.52	5.6	20.1
	Blood	7.45	4.1	8.1
	Biopsy: Questionable calcification			

Sept. 25, 1943	Hematoma	7.51	7.4	44.0
	Blood	7.49	4.8	1.9
	Biopsy: Questionable calcification			
Oct. 4, 1943	Hematoma	7.52	5.6	20.1
	Blood	7.45	4.1	8.1
	Biopsy: Questionable calcification			

Fracture No. 215–43

Oct. 11, 1943	Hematoma*	7.28	8.6	3.5
	Blood	7.45	6.1	4.4
Oct. 12, 1943	Hematoma	7.25	5.4	6.6
	Blood	7.48	4.3	5.3
Oct. 14, 1943	Hematoma	7.29	4.9	2.2
	Blood	7.42	4.9	6.1
Oct. 16, 1943	Hematoma	7.24	4.9	2.7
	Blood	7.41	4.9	2.7
Oct. 18, 1943	Hematoma	7.51	5.6	16.1
	Blood	7.49	5.1	3.9
Oct. 20, 1943	Hematoma	7.46	4.4	10.0
	Blood	7.44	3.9	3.5
	Biopsy: Definite calcification			

Fracture No. 333–43

Dec. 17, 1943	Hematoma†	7.36	5.4	3.7
	Blood	7.49	4.0	4.9
Dec. 18, 1943	Hematoma	7.36	5.5	5.0
	Blood	7.39	4.3	3.5
Dec. 20, 1943	Hematoma	7.25	6.5	7.3
	Blood	7.35	4.7	3.2
Dec. 22, 1943	Hematoma	7.30	5.6	1.7
	Blood	7.40	4.3	3.0
Dec. 24, 1943	Hematoma	7.41	5.3	16.2
	Blood	7.41	3.7	1.4
Dec. 27, 1943	Hematoma	7.54	5.5	14.8
	Blood	7.36	4.8	4.3
	Biopsy: Definite calcification			

Fracture No. 309–43

Nov. 19, 1943	Hematoma†	7.35	6.9	4.8
	Blood	7.48	5.9	3.6
Nov. 20, 1943	Hematoma	7.08	15.7	4.6
	Blood	7.42	4.9	4.8
Nov. 22, 1943	Hematoma	7.24	7.9	4.2
	Blood	7.41	5.4	3.7
Nov. 24, 1943	Hematoma	7.31	9.2	6.8
	Blood	7.41	7.1	5.6
Nov. 26, 1943	Hematoma	7.41	6.8	16.6
	Blood	7.38	4.9	7.4
	Biopsy: Definite calcification			

Fracture No. 3–44

Jan. 5, 1944	Hematoma†	7.15	5.9	1.4
	Blood	7.33	2.6	2.4
Jan. 6, 1944	Hematoma	7.13	4.6	1.5
	Blood		2.9	2.6
Jan. 8, 1944	Hematoma	7.30	4.2	2.3
	Blood	7.46	3.4	1.1
Jan. 10, 1944	Hematoma	7.34	4.8	7.6
	Blood	7.39	3.8	2.0
Jan. 12, 1944	Hematoma	7.44	4.5	4.7
	Blood	7.44	4.2	1.9
Jan. 14, 1944	Hematoma	7.54	5.7	19.9
	Blood	7.45	4.4	3.2
	Biopsy: Definite calcification			

* Two and one-half hours after fracture.
† Three hours after fracture.

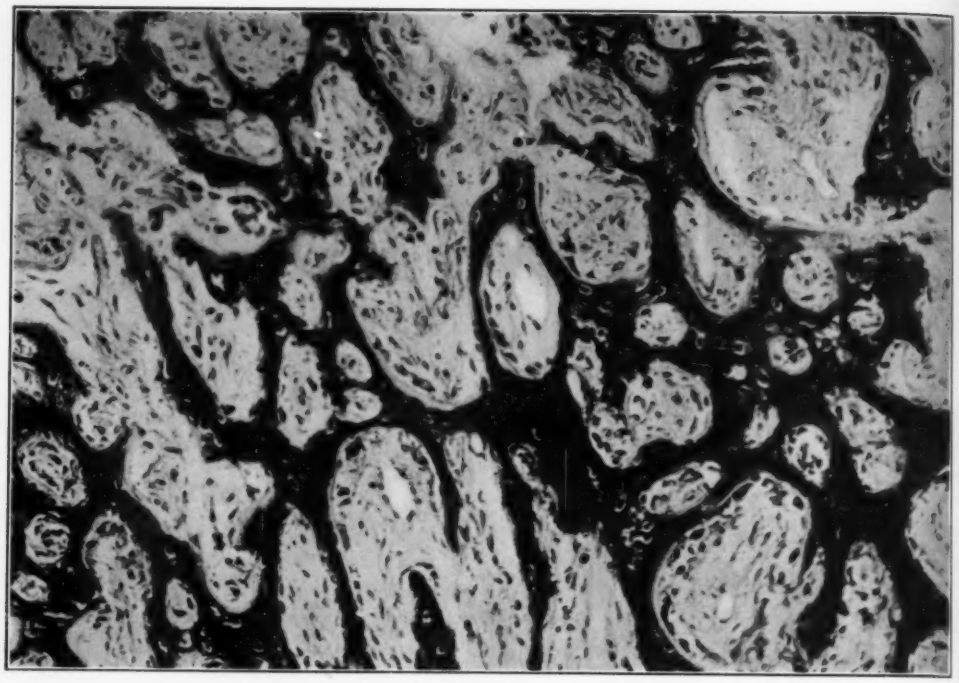

FIG. 1

Photomicrograph of section from Fracture No. 127–43, taken at the end of the experiment (ninth day). Section was stained for calcium by the Kossa technique; calcification is well demonstrated.

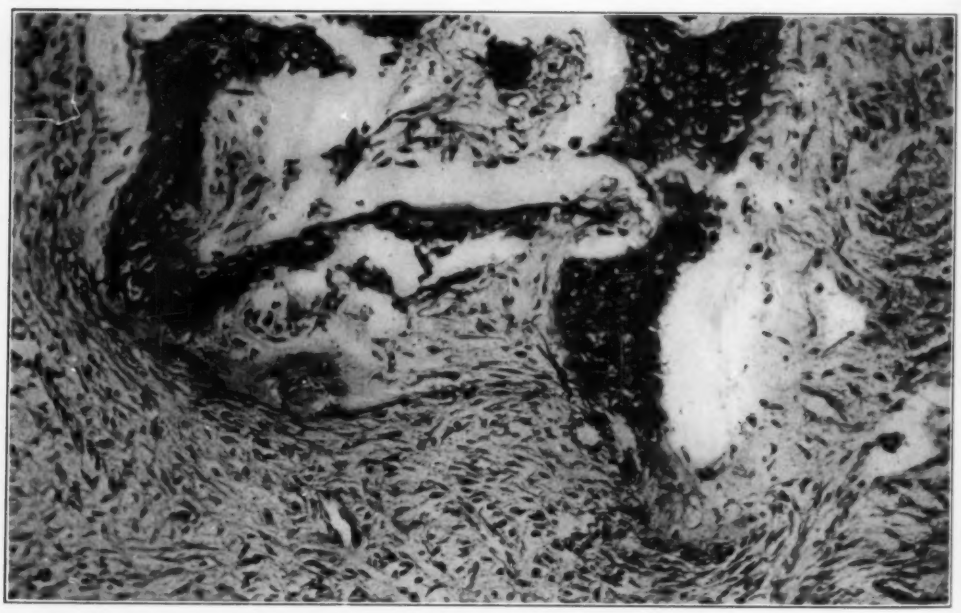

FIG. 2

Photomicrograph of section of tissue removed from Fracture No. 220–43 at the end of the experiment (fifteenth day). Calcification is well demonstrated by the Kossa staining technique.

marked increase in the inorganic-phosphorus level. This value was as high as 18.7 milligrams per 100 cubic centimeters for the hematoma fluid, whereas the circulating venous blood has a level of from three to four milligrams per 100 cubic centimeters. Within the

next forty-eight hours the inorganic-phosphorus level in the hematoma fluid had fallen to a concentration which approximated the level in the venous blood. The inorganic-phosphorus determination remained at about the same value in the hematoma fluid and in the venous blood until the seventh to tenth day, when there was an increase in the inorganic phosphorus in the hematoma fluid. At the end of the experiment, the value for the hematoma fluid was as high as 7.4 milligrams per 100 cubic centimeters, which was almost twice the level in the venous blood.

The alkaline phosphatase had a rather characteristic curve (Chart I). Soon after the fracture had been produced, the phosphatase level in the hematoma fluid was about the same as that in the circulating blood, or lower. It was maintained at about the same level as in the venous blood until the seventh to the fifteenth day, at which time there was a marked elevation in the phosphatase activity, with values as high as fifty-six Bodansky units.

In correlating these three determinations—that is, the pH, the inorganic phosphorus, and the alkaline phosphatase—it was found that, as the pH became alkaline, there was a marked increase in the amount of alkaline phosphatase and a moderate increase in the inorganic-phosphorus level in the hematoma fluid. Biopsies were made of the fracture material, and in six out of eight fractures there was definite calcification (Figs. 1 and 2). In the remaining two there was questionable calcification. There was no demonstrable calcification in a series of six fractures from which material for biopsy was obtained prior to these biochemical changes,—that is, before there was elevation in the alkaline phosphatase.

DISCUSSION

These experiments support the thesis that alkaline phosphatase is involved in the process of calcification, as seen in fracture repair. The experimental evidence would indicate that the phosphate-ion concentration is increased, at the site of calcification, by a complex enzyme mechanism in which alkaline phosphatase is involved. This is contrary to the theory of fracture healing proposed by such workers as Stirling and Murray. They postulate that the high local acidity at the fracture site produces an ideal medium for an increase of calcium, and that the subsequent change to local alkalinity in the fracture hematoma promotes precipitation of the calcium phosphates. No actual direct measurement of calcium concentration is reported to support this theory. The pH changes may affect the calcium-ion concentration in the fracture hematoma, but there are probably more decisive changes in the phosphate-ion concentration, which make possible a precipitation of some form of calcium phosphate.

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SARCOID OF BONE

Report of a Case

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Royal Canadian Army Medical Corps

CLINICAL FEATURES

Sarcoid of bone (also known as Jüngling's disease and Boeck's sarcoid) is seen most frequently in young adults, particularly in males. The onset is usually insidious. The bones of the hands and feet are most commonly affected, but cases have been reported which involved the long bones. There may be no external evidence of the disease, but usually there is irregular enlargement of the fingers or toes. Subcutaneous nodules may appear about the interphalangeal joints, and in advanced cases there may be gradual disappearance of the terminal phalanges. Pain may be present in the early stages, but it is never severe. The roentgenographic changes are so characteristic that they may be easily identified by anyone who is familiar with the disease.

Jüngling described three main roentgenographic pictures, although intermediate and mixed forms are common. Type 1 is a diffuse mottling or speckling of the affected bone, sometimes showing slight expansion of the cortex. Type 2 is characterized by a punched-out appearance, which gives the impression of translucent cysts in the substance of the bone. These cysts tend to fuse and to form larger cysts, but they seldom involve the periosteum or the joints. The punched-out areas, however, are not cystic in the true sense of the word, but contain semisolid granulation tissue—a fact which caused Jüngling to substitute the word *cystoides* (cystlike) for cystica in his second paper. Type 3 shows a loss of density and a latticework appearance (*Gitterstruktur*) in the substance of the bone, without any alteration of the contour.

PATHOLOGICAL CHARACTERISTICS

On pathological examination, the lesions appear as semisolid granulation tissue, characterized histologically by the presence of clumps of epithelioid cells, arranged in tubercle formation and surrounded by lymphocytes. Giant cells may be in evidence, but actual necrosis of tissue is not seen and the *Mycobacterium tuberculosis* cannot be demonstrated in the lesions. The constitutional reaction is seldom marked, and the blood picture is not characteristic. Salvesen observed an elevation of the level of total protein in the serum in three out of four cases of generalized sarcoidosis, but his observations have not been substantiated by others. Although the disease runs a chronic course, it exhibits a natural tendency to improvement, and over a period of years complete healing may take place.

ETIOLOGY

The origin of the group of lesions to which sarcoid of bone belongs is still obscure. Most writers have emphasized the resemblance to tuberculosis, but the *Mycobacterium tuberculosis* has seldom been found in the lesions and, when present, has been regarded as a purely incidental finding. The intradermal tuberculin reaction is usually negative, and Jadassohn has postulated a "positive anergy" for the disease. This hypothesis is supported in the report of a case by Schaumann, in which the patient contracted pulmonary tuberculosis of bovine origin, which led to the spontaneous disappearance of sarcoids of the skin, lymph nodes, and fingers. Lemming injected a large dose of living BCG vaccine into a typical case of uveoparotitis and caused a local reaction, with enlargement of the regional lymph nodes. In this case the Mantoux test remained negative, even after the injection of

five milligrams of old tuberculin; one of the nodes, which was excised for section, showed the characteristics of Boeck's sarcoid. Repeated injections of large doses of BCG vaccine into another patient with enlarged mediastinal nodes failed to alter the negative Mantoux test.

From this evidence, it is tempting to postulate that the causal organism of this group of diseases may be an attenuated strain of the *Mycobacterium tuberculosis*, but the difficulty of interpreting such findings comes to light when it is recalled that Sabin, Doan, and Forkner were able to produce a reaction in connective tissue, similar to that of sarcoid, by experimental injection of the phosphatide fraction A-3, derived from the lipoid envelope of the *Mycobacterium tuberculosis*. Murdock and Hutter state that the bony changes in the hands and feet closely simulate those of leprosy, but the *Mycobacterium leprae* has not been found in the lesions; and Pautrier reports that tissue inoculated into guinea pigs and Macacus monkeys has given negative results. In summary, although most observers regard the disease as an atypical form of tuberculosis, there is little direct evidence to support their contention.

DIFFERENTIAL DIAGNOSIS

The roentgenographic appearance is sufficiently characteristic to render the diagnosis of sarcoid of bone fairly simple. The few conditions with which it could be confused are as follows:

1. *Dactylitis Tuberculosa*: Dactylitis tuberculosa usually occurs in infants, whereas sarcoid of bone is seen in adults or adolescents. Dactylitis tuberculosa is associated with greater deformity of the bones and with necrosis; caseation and sinus formation are usually evident. The cutaneous tuberculin test is usually negative in sarcoid of bone, and *Mycobacterium tuberculosis* cannot be demonstrated in the tissues.

2. *Leprosy*: The lesions of leprosy are associated with severe destructive osteitis of the phalanges and irregularity of the interphalangeal joints. The nutrient foramina of the bones are unduly prominent in leprosy.

3. *Syphilis*: The diagnosis of syphilis can be established by means of serological reactions and by other evidences of the disease.

4. *Gout*: The diagnosis of gout is usually evident from the history, the blood chemistry, and the response to treatment.

5. *Traumatic Cysts*: Brailsford has described the occurrence of cysts in the carpal bones of men who have used compressed-air drills for ten years or more. In these cases the history of occupational exposure to prolonged trauma should be readily available.

TREATMENT

The question of specific therapy can be dismissed in three words: There is none. Arsenic, ultra-violet light, roentgen rays, and radium have all been tried, without benefit. Chaulmoogra oil has been used, because of the resemblance of the lesions to those of leprosy, but beneficial results have not been reported. It will be remembered that the disease shows a tendency to spontaneous improvement.

CASE REPORT

On February 8, 1945, F. W., aged twenty-four years, a gunner in the Royal Canadian Artillery, was admitted to Montreal Military Hospital, complaining of pain in the left wrist. He stated that he had been perfectly well until 1941, when he was driving a heavy army truck over a rutty road and the steering wheel suddenly "spun", twisting his left wrist. No roentgenograms were taken. The wrist remained painful for a week, and during that time he wore a simple bandage for support. After this accident he noticed that his left wrist was weak, and he experienced pain in the wrist when he lifted anything heavy or attempted to bear weight on the wrist. Two years before admission to the Hospital, a lump appeared on the volar surface of the wrist, but it did not increase appreciably in size. The wrist

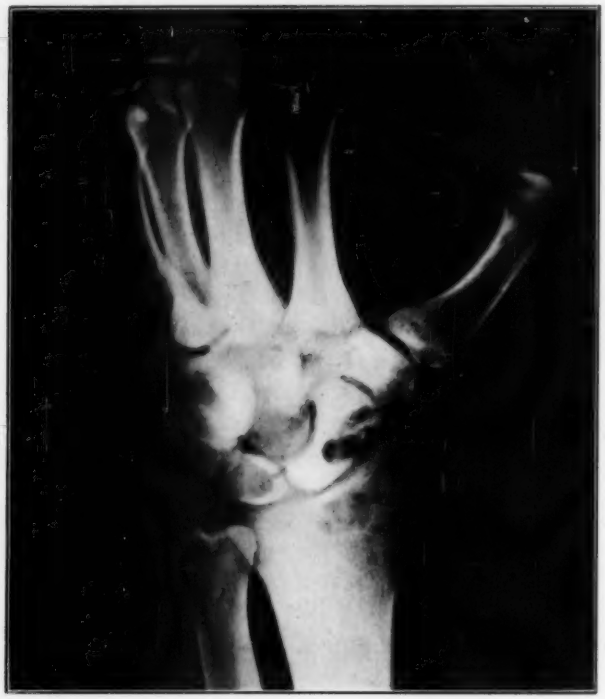

FIG. 1

Roentgenogram of the left wrist. Note the cystlike areas in the lower end of the radius and in the carpal bones. Those in the metacarpals are not well demonstrated in this plate.

gradually became more painful, and shortly after D-day it began to be stiff. At that time the patient was on active service in France, and he was able to continue his regular duties without appreciable disability. In October 1944, an upper respiratory infection developed and he was admitted to a general hospital overseas. While there, roentgenograms were made of the left wrist. A cystic condition of the carpal bones was discovered, and the patient was repatriated to Canada.

The family history was non-contributory. The patient's father and mother were alive and well. Eight siblings were alive and well. One sister had died of pneumonia. There was no history of tuberculosis, cancer, or diabetes among the immediate relatives. The patient denied any serious illness in the past, and had never been subjected to surgical operation.

General physical examination was essentially negative. The patient appeared to be a healthy, vigorous, young adult male. The skin was healthy, there was no evidence of disease in the chest, nor any enlargement of the lymph nodes, liver, or spleen.

Examination of the left wrist showed a fluctuant, tender swelling, measuring about one centimeter in diameter, situated on the volar surface of the left wrist, just distal to the styloid process of the ulna. It was not attached to the skin, but seemed to arise from the deeper tissues, to which it was firmly adherent. There was no local heat or other sign of inflammatory reaction. There was no wasting of the left arm, but the grip of the left hand was less than normal. Dorsiflexion was limited by 15 degrees; palmar flexion was limited by 20 degrees and caused pain in the volar aspect of the wrist. Supination and pronation were full and painless. There was an area of acute tenderness to palpation over the scaphoid bone and over the mass, just distal to the ulnar styloid.

Roentgenograms of the left wrist, taken on February 2, 1945, showed small areas of bony destruction, cystlike in appearance, which formed punched-out lesions involving the triangular bone, the greater multangular, the capitate bone, the lower extremity of the radius, and the bases of the second and third metacarpals (Fig. 1). The joint spaces were free and there was no peculiarity of the soft tissues. The remainder of the skeleton was examined under the fluoroscope, but no other abnormalities were detected. Fluoroscopic examination of the chest was reported as negative.

The urinalysis was reported as negative. The blood examination was as follows:

Red blood cells	5,070,000
Hemoglobin	95 per cent.
White blood cells	9,050
Polymorphonuclear neutrophils	
Segmented	61 per cent.
Non-segmented	5 per cent.
Monocytes	4 per cent.
Lymphocytes	27 per cent.
Eosinophils	3 per cent.
Coagulation time	4 minutes and 23 seconds
Bleeding time	2 minutes and 33 seconds

The sedimentation rate was five millimeters per hour. The Wassermann reaction was negative.

On March 3, a biopsy was performed (by D.R.M.) on tissue from the swelling on the front of the

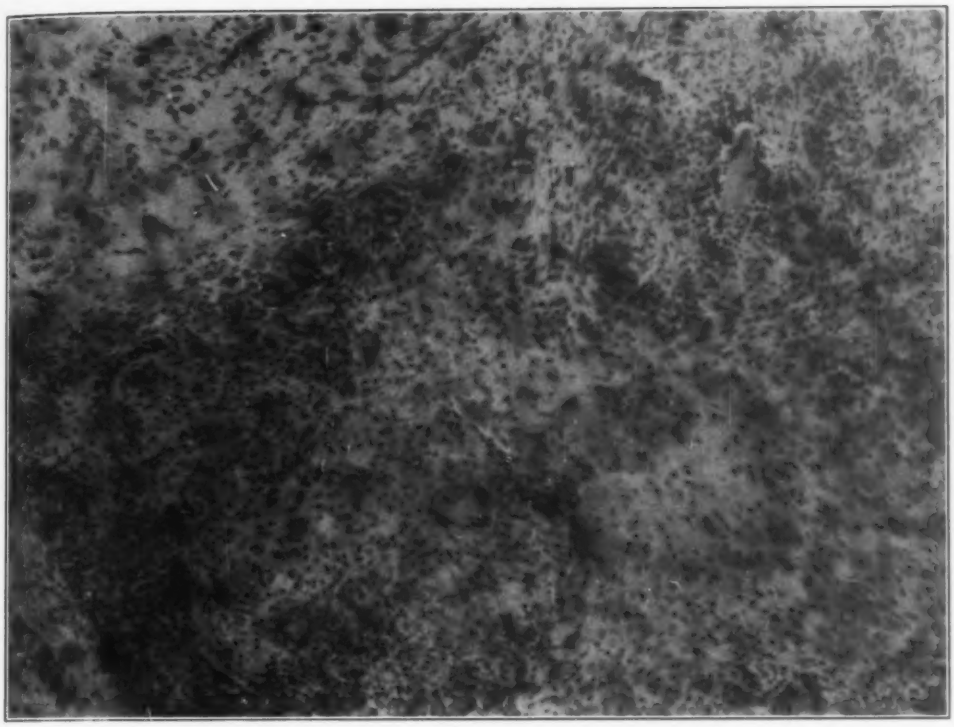

FIG. 2

Photomicrograph of excised tissue. Note islands of epithelioid cells, surrounded by lymphocytic infiltration. A giant cell is visible near the center of the field. There is no evidence of coagulation necrosis.

left wrist. The mass was found to consist of muddy, soft, yellowish granulation tissue. Histological examination was made, and all sections showed fibrous tissue in which there were focal areas of granulomatous inflammation. This expressed itself as clusters of epithelioid cells and occasional giant cells. The *Mycobacterium tuberculosis* was not seen in any of the sections. There was no coagulation necrosis (Fig. 2).

The wound which had been produced when tissue was removed for biopsy healed by first intention, and on March 29 the patient was discharged from the Hospital, to begin thirty days' disembarkation leave.

He was readmitted to Montreal Military Hospital on May 2, still complaining of slight pain in the left wrist. Examination showed that there had been no change in the power and movement of the wrist. The wound caused by removal of the tissue for biopsy was well healed. An intradermal tuberculin test was performed, using 0.5 milligram of old tuberculin; when read, forty-eight hours later, it gave a negative result. A roentgenographic examination, on May 4, showed both lung fields to be clear. There was some evidence of healing, especially at the lower end of the radius and in the scaphoid bone.

COMMENT

This case illustrates most of the points which Jüngling held to be characteristic of sarcoid of bone. The history of trauma to the wrist in 1941 was probably incidental, and it is doubtful whether it had any direct bearing on the development of the disease. Trauma has not been regarded of etiological significance by any of the authors who have written about the disease. In typical cases of sarcoid of bone, the bone lesions are predominantly in the metacarpal bones and phalanges of the hands and in the metatarsal bones and phalanges of the feet, but cyst formation in the bones of the carpus is well shown in one of the roentgenograms depicted in Jüngling's second paper. The insidious onset of the condition, and the relative absence of disability in the early stages, are brought out well when it is appreciated that this soldier sought no medical care for his wrist for a period of

four years, and was able to carry out the full duties of a gunner, even under the arduous conditions of the D-day landing on the coast of France, without apparent disability.

The roentgenographic picture of multiple cysts in the bones of the carpus, the metacarpals, and the bones of the forearm fits in well with Jüngling's Type 2 lesion. The tendency of the cysts to fuse and to form larger cysts is well borne out. Both macroscopically and microscopically, the biopsy specimen exhibited the lesions in typical form. The absence of caseation and the failure to demonstrate the *Mycobacterium tuberculosis* are both characteristic of the disease. Skin lesions and lymph-node enlargement, although frequently found in association with the osseous cysts, were not present in this case. The intradermal tuberculin test was negative, which is the usual finding in this disease. No specific treatment is known to have had any effect upon the disease.

The patient will be discharged from the Army and arrangements will be made for his return to civilian life. Meanwhile, the forearm and wrist will be immobilized in a plaster-of-Paris cast from the metacarpophalangeal joints to the fold of the elbow, with the wrist in the position of optimum function. The most recent roentgenograms showed more evidence of healing than those taken a month previously, and it is hoped that healing will be accelerated by placing the diseased part at rest.

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SPASMODIC TORTICOLLIS

Severe Organic Type Treated by Combined Operation, Rhizotomy, and Fusion *

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The term "spasmodic torticollis" is applied to a group of manifestations consisting of spasm of one or more muscles of the neck. These manifestations may result from emotional instability; from an organic lesion affecting the basal ganglia, peripheral nerves, or muscles; or from a combination of these factors. Not infrequently the discomfort and disability become so severe that surgical intervention is required.

Numerous surgical procedures have been employed, but, in extreme cases, extensive rhizotomy of the upper cervical nerves and section of the spinal accessory nerves become necessary. Occasionally, bilateral section of the upper three cervical nerves, combined with section of both spinal accessory nerves, results in subluxation of the upper cervical vertebrae which interferes with swallowing, breathing, and talking. When this occurs, a method of fixation to prevent the subluxation becomes necessary. The procedure outlined here has been employed to correct this deformity and to relieve spasm of the organic type.

ETIOLOGY

The etiology of the various types of spasmodic torticollis is not clearly defined, although it is agreed generally that two factors are responsible for the muscle spasm: (1) psychogenic or emotional imbalance (psychogenic or functional type) and (2) structural changes in the neuron system supplying the muscles affected (organic type). Rugh has stated that the psychogenic type is due to mental or physical stress in a neurotic person. The inherent instability of the nervous system, whether it be congenital or acquired, renders the nerve cells at the base of the brain especially susceptible to external stimuli from occupation or surroundings. He further stated that the cells are in a state of debility or exhaustion from overuse, which renders them susceptible to irritative and stimulative external conditions, but which is not followed by degenerative or pathological changes in the cells.

Spasmodic torticollis, resulting from structural change in the neurons to the affected muscles, may vary in character. Hyslop stated that torticollis of peripheral origin is due to a disorder in innervation. According to him, the defect may lie in the peripheral reflex arc and may be due to some form of inflammatory lesion, affecting either the muscle itself or the segments of the peripheral-nerve trunks supplying the muscle. Occasionally the spasm may be a compensatory reflex, such as occurs in certain types of extra-ocular paresis or imbalance. Instances have been described in which the stimulus which causes the muscle spasm apparently originates in the vestibular apparatus. Grinker made the statement, however, that the labyrinthine disturbance probably is due to a unilateral lesion of the brain stem. Rugh further stated, in a discussion of torticollis of central origin, that the torticollis represents the end result of stimuli. These stimuli may originate either in the cerebral cortex (which may be structurally perfectly healthy), or they may arise out of some structural or physiological alteration of function in the basal ganglia. He further observed that the severity of torticollis of central origin shares with certain other types of abnormal movements the tendency to vary with alterations in the patient's state of mind. He suggested that torticollis of central origin may be the result

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of certain primary infections of the nervous system. In particular, epidemic encephalitis is known to produce the symptoms. Alpers and Drayer found pathological changes in the large cells of the caudate nucleus and the putamen. It is generally agreed that, in the functional type of spasmodic torticollis, no changes occur in the affected muscles or fascia; whereas, in the organic type, pathological changes may occur. In dystonia following encephalitis, spasmodic torticollis may be only part of the clinical picture. Congenital torticollis is believed to be due to anomalous development, plus structural changes in the muscles characterized by contractures. The condition frequently referred to as wry-neck invariably is the result of myositis.

SYMPTOMS AND SIGNS

Spasmodic torticollis may involve one or more muscles of the neck, and the spasms may be tonic or clonic, or a combination of both. At the onset, the muscles on one side may be affected, but the condition may progress to involve the muscles on both sides. The muscles usually affected are those supplied by the spinal accessory nerves and the motor branches of the upper three cervical nerves. The sternocleidomastoid, the trapezius, and the splenius are the muscles which usually produce the deformities of which patients complain. When smaller muscles are affected, the abnormal positions of the head are less pronounced. Unilateral spasm of the sternocleidomastoid and trapezius muscles results in rotation of the chin to the opposite side, in an upward and outward direction. When the splenius muscle is involved on one side, the head is retracted posteriorly and to the same side. When the muscles on both sides are involved, the chin may first be tilted in one direction and then in the other. One side is usually affected more severely than the other. In the organic type, the spasms are more tonic than clonic. Pain is a frequent and severe symptom in the advanced stages. The continued tonic or clonic spasm results in marked hypertrophy of the muscles involved. Accompanying hypertrophy is a fibrotic change, which results in permanent contractures in many cases. These are not relieved by nerve section, but require, in addition, tenotomy and myotomy of some muscles.

The progress of the disease is not constant. In some cases the disease may gradually involve adjacent muscles and remain unilateral, while in others it may progress to muscles of the other side. Occasionally the muscles on both sides are affected equally at the same time. If the patient has had encephalitis, it is possible that the torticollis may be the initial postencephalitic symptom; therefore, caution should be employed in advocating any radical treatment, since other muscles, especially those of the trunk, may become affected subsequently and the patient may be further incapacitated. In all cases, the symptoms subside when the patient is asleep. Often the patient controls the clonic spasms by supporting the chin with the hand or by resting the head on the back of a chair. The symptoms invariably are exaggerated when the patient meets strangers, is being observed by physicians, or is subjected to emotional strain.

DIFFERENTIAL DIAGNOSIS

The most difficult problem in the study of patients suffering from spasmodic torticollis is to determine whether or not the manifestations are of psychogenic or organic origin. It is extremely important to make this distinction, because surgical procedures are not justified in the psychogenic type of case. At the Mayo Clinic, these patients are studied carefully from general physical, neurological, and psychiatric points of view before treatment is recommended.

A review of a patient's medical history is extremely essential for, if remissions in the course of the disease have occurred, the condition is probably of psychogenic origin. The medical history will reveal the relationship of the onset of symptoms to the patient's emotional reactions to his environment.

After the psychogenic factors have been investigated, it is necessary to determine the presence of any previous cerebral or meningeal diseases or injuries to the brain, nerves, or muscles. If any such diseases have occurred, they would point toward an organic basis for the development of the patient's symptoms. Even though there is an organic basis, the symptoms are usually exaggerated by the emotional reaction of the patient. In the organic type, the spasm is more likely to be tonic than clonic, and furthermore, hypertrophy of the affected muscle is greater than it is in the functional type. In the psychogenic or functional type, the patient is inclined to toss his head from side to side, the movements are jerky, and the muscles are more easily relaxed than when the lesion is of the organic type. When the symptoms are of organic origin, contraction of the muscles will begin in a slow movement, spread until the height of a contraction is reached, and continue for a much longer period than it does when the condition is of functional origin.

Nerve block with procaine hydrochloride has been used in an attempt to differentiate further between the psychogenic and organic types. In the organic type, spasm in the muscle disappears when the nerves are completely anaesthetized, while in the functional type, in spite of thorough anaesthetization of the nerves, the patient will continue to toss or jerk the head in a series of abnormal movements. Though this response to the test is not absolutely pathognomonic of an organic lesion, the test is of value in differentiating between organic and functional types.

Unilateral block of the spinal accessory nerve and the upper three cervical nerves with procaine hydrochloride is of additional value in determining the presence or absence of spasm, or the degree of spasm on the side opposite to the muscles chiefly involved. Thorough relaxation of the affected muscles permits the opposite group to perform without interference. This test is significant, because unilateral section of the spinal accessory nerve would not be advisable if the muscles on the opposite side are affected also.

TREATMENT

Conservative Measures

The treatment of spasmodic torticollis is based upon the severity and duration of symptoms and the type of torticollis present. Since types may overlap, a conservative course of treatment should be employed first in all cases. By conservative treatment is meant the use of a medical regimen before any surgical procedure is advocated or performed. The medical regimen usually consists of prolonged rest, change of vocation, and the use of physical therapy; the administration of drugs, such as belladonna (rabellon), scopolamine, phenobarbital, vitamin B (especially nicotinic acid), and occasionally quinine; and the use of a plaster cast to immobilize the head and neck.

The authors' experience with the conservative treatment of spasmodic torticollis has not been encouraging, particularly in cases of the organic type. This experience covers use of traction to the head when the patient is recumbent in bed, various types of braces to support the head, and plaster casts; as well as physical therapy, including massage, diathermy, electrotherapy, and exercises. Many of the patients were more comfortable and often the spasmodic contractions ceased when they were in bed, especially if traction had been applied to the head. In no instance, however, was improvement of a permanent nature derived from such treatment.

Some years ago, after encouraging reports had appeared on the results of prolonged fixation in plaster-of-Paris casts, this method of treatment was tried in several cases. In most instances, the casts were applied carefully with the patients under general anaesthesia to ensure maximum relaxation. The casts covered the head and shoulders and, in some cases, extended down to the level of the lowest rib; in other cases they extended to the pelvis. Most of the patients could not or would not tolerate the casts for more than a few days, and it became necessary to remove them. In one or two cases the casts were

tolerated for a long period. In one case in which a cast was tolerated for several months, some benefit was thought to have followed its use, but it is doubtful whether the cast had any more to do with the improvement than the enforced prolonged rest. The case was one of extensive muscular dystonia with maximal spasm in the neck, and was not one of a strictly localized spasmodic torticollis. Our efforts with plaster-of-Paris casts, therefore, were discouraging. The same may be said of various types of braces to support the head. It is almost impossible to make a brace that holds the head steady, and the constant tugging and irritation are more than the patient can tolerate, except in the mildest cases.

In some instances of functional origin, these conservative measures have been found helpful and usually can be tolerated. The diagnosis of a functional type of spasmodic torticollis, therefore, justifies the use of such measures for a long period.

Surgical Treatment

When conservative measures fail in the treatment of the organic type, and when the symptoms are severe enough to produce pain and interfere with normal activity, operation must be considered, especially if an organic basis for the symptoms has been found.

Various operative procedures have been employed. The indications for each depend on the degree of spasm and contracture present and the extent of involvement. The operative procedures used, which will be mentioned in more detail, are as follows: unilateral section of the spinal accessory nerve in the neck; bilateral section of the spinal accessory nerves; section of one or more spinal accessory nerves, combined with section of the upper three cervical nerves as they leave the intervertebral foramina; section of the spinal accessory nerves and cervical nerves, with tenotomy and myotomy of the contracted muscles; combined operation, which includes an intracranial bilateral section of the spinal accessory nerves and rhizotomy of the upper three cervical nerves through a laminectomy wound; and a bone graft placed in the occipitocervical field after section of the spinal accessory nerves and rhizotomy of the upper three cervical nerves, when evidence of a subluxation of the upper cervical portion of the spinal column is found following extensive section of nerves.

Single or bilateral sections of the spinal accessory nerves are employed only when the sternocleidomastoid and the trapezius appear to be the muscles chiefly affected. The additional section of the cervical nerves is resorted to when the splenius capitis, the splenius cervicis, and the levator scapulae muscles also appear to be included in the unilateral spasm complex. The results of these procedures are not too gratifying, but they reduce the spasm to such an extent that the patient is able to carry on with his work.

In this series, section of the spinal accessory nerve was performed in twenty-one cases. In two, bilateral section was performed. One patient was completely relieved, sixteen were improved, and four obtained no relief. In four additional cases, cervical unilateral section of the spinal accessory nerve and the upper three cervical nerves was performed, and little or no relief was obtained.

If satisfactory relief is to be obtained when several muscles on both sides of the neck are affected, a major procedure is necessary. This procedure consists of bilateral section of the spinal accessory nerves and bilateral rhizotomy of the motor roots of the upper three cervical nerves. In some cases in which this procedure has been employed, the spinal accessory nerves have been divided in the cervical region prior to laminectomy and rhizotomy. The nerves were identified on the mesial side of the sternocleidomastoid muscle before they entered the muscle. The rhizotomy was performed through a laminectomy incision, which consisted of bilateral removal of the lamina of the first and second cervical vertebrae. No difficulty ever is encountered in identifying the second and third cervical roots, but occasionally the first cervical motor root may be overlooked, since it is intimately associated with, and lies anterior to, the vertebral artery as it enters the cranial cavity.

Intraspinal section of the spinal accessory nerves has not always been satisfactory, because section of these nerves at the level of the first cervical nerve root has not included all of the motor fibers passing into the nerve. For this reason, intracranial section of the

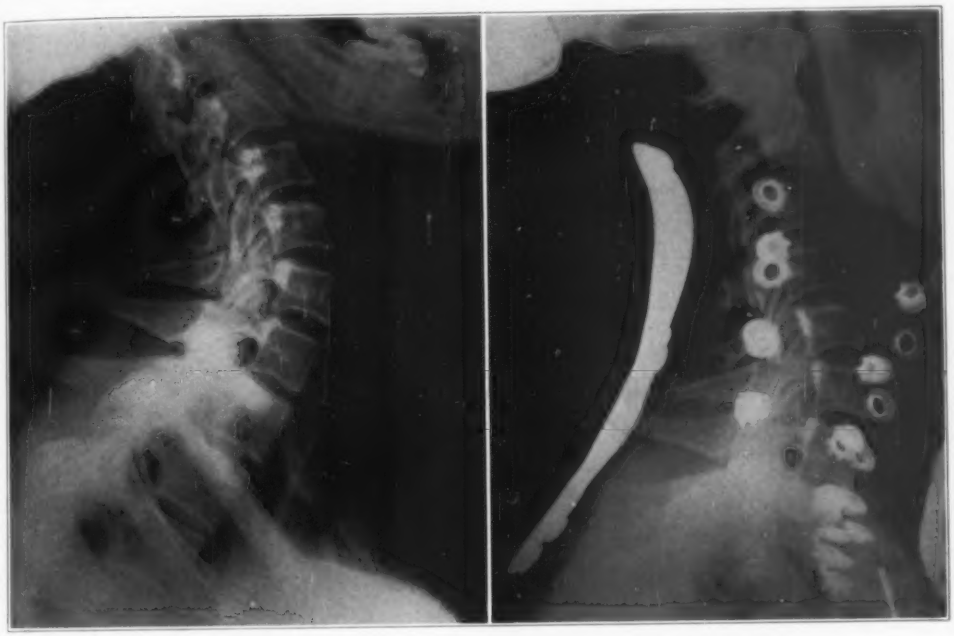

FIG. 1-A

Subluxation with anterior curvature of upper cervical vertebrae.

FIG. 1-B

Correction of subluxation by wearing a celluloid collar.

spinal accessory nerves just as they enter the jugular foramina has been performed. This extensive procedure of bilateral intracranial section of the spinal accessory nerves, and bilateral rhizotomy of the upper cervical roots, has given some satisfactory results. The muscle spasms have been completely relieved, without too much interference with the movements of the head and without too much deformity from atrophy. In certain cases, however, subluxation with anterior curvature of the upper cervical vertebrae has resulted; the patient's head has fallen forward; and the mandible has pressed into the neck in such a manner as to interfere with breathing, swallowing, and speaking (Fig. 1-A). This deformity may be corrected partially by the wearing of a Thomas collar or an especially adapted celluloid collar (Fig. 1-B). Patients object to wearing this collar for the rest of their lives, however. The subluxation is most likely to occur in cases in which the patient

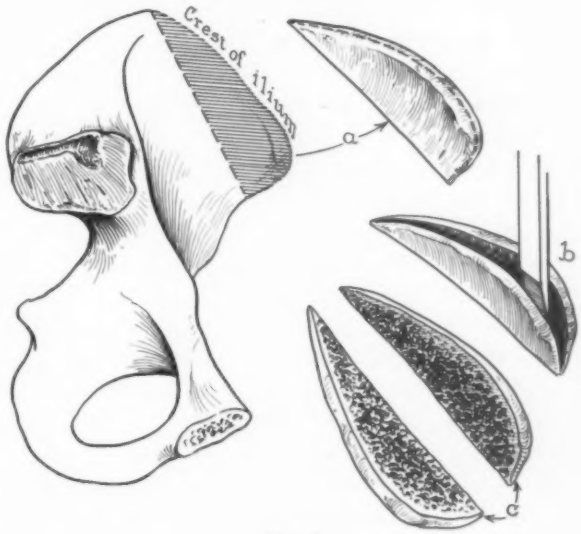

FIG. 2

a: Removal of the bone graft from the crest of the ilium.

b and *c*: Further preparation of the bone graft by dividing it into two parts.

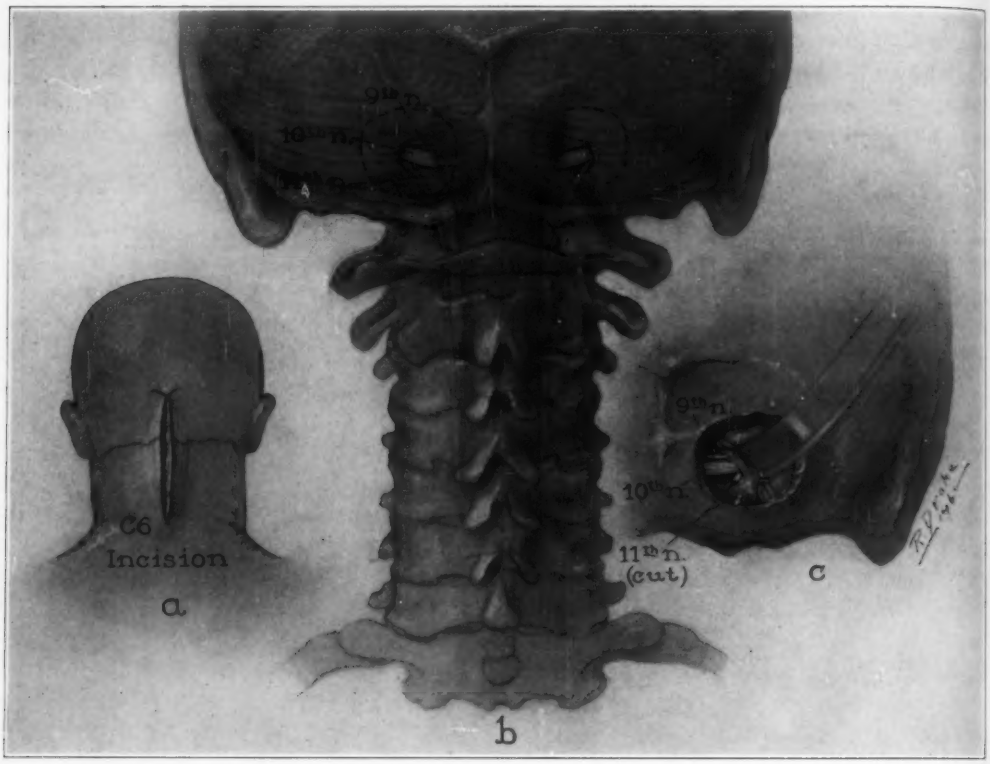

FIG. 3

a: The incision employed to expose the occipital bone and upper cervical portion of the spinal column.

b: The positions of the two trephine craniotomies employed in sectioning the spinal accessory nerves.

c: The site of the intracranial section of the spinal accessory nerve.

has a rather large and heavy head, because the weight of the head causes it to tilt forward on the cervical portion of the spinal column. Subluxation also occurs in patients who are compelled to perform heavy manual labor and in persons who frequently shift the position of their bodies in performing their duties.

The complaint of forward displacement of the head with difficulty in breathing, swallowing, and speaking, plus the nuisance of wearing a collar, prompted the authors to devise an operative procedure which included bilateral intracranial section of the spinal accessory nerves (Fig. 3) and bilateral rhizotomy of the upper three cervical nerves (Fig. 4), with the introduction of a bone graft which had been taken from the ilium and placed in the occipitocervical space. The graft was shaped so that it could be transfixed to the postero-inferior surface of the occipital bone, placed laterally over the ends of the first and second cervical laminae, and lateral to the spines of the cervical vertebrae over the third, fourth, and fifth cervical laminae.

Bone from the iliac crest is most suitable for the bone graft. Bone from the anterior portion of the iliac crest is preferred, as a longer piece of bone can be obtained than from the posterior portion. The first step of the bone-grafting part of the operation is carried out with the patient in the supine position. An incision is made along the anterior third of the iliac crest to a point one inch (2.5 centimeters) below the anterior superior spine. The muscle is carefully dissected from the iliac crest and the anterior superior spine for a distance of about three inches (7.6 centimeters). The ilium is stripped free of all attachments downward for about one inch from the crest, and this portion of the ilium is removed with

FIG. 5

FIG. 4

Fig. 4: *a*: The anatomical relationship of the upper three cervical nerves to the vertebral artery and the spinal accessory nerve. *b* and *c*: The bilateral rhizotomy of the first and second cervical nerves and the motor root of the third cervical nerve.

Fig. 5: *a*: The procedure employed in preparing the field; shaping the graft, with its introduction and fixation; and securing it in position by wiring the upper end of the graft to the occipital bone with heavy non-corrosive wire. *b*: The relationship of the bone grafts to remaining portions of the lamina and to each other.

a sharp osteotome. The graft then is split longitudinally, as shown in Figure 2. As a rule, the graft is found to fit fairly well into the bed prepared for it and the contour of the anterior superior spine fits well into the occipito-atloid angle. Before placement of the graft, holes are drilled in both upper ends in order to pass the wire through the graft, as well as through the holes previously made in the skull lateral to the mid-line. Half of the graft is placed on each side of the vertebra to act as a roof over the spinal canal. The wires are passed through the two pieces of the graft and the holes in the occiput, and are twisted until they hold the graft snugly against the occiput and atlas. The grafts may be trimmed along their border to ensure accurate fitting against the other cervical vertebrae (Fig. 5).

Where a sufficient amount of lamina is left, the edge of the graft can be placed firmly against it and, when the upper end of the graft is fixed, the danger of slipping is minimized (Fig. 6). The lower end of the graft is held in place by suturing the muscles firmly over it.

After closure of the wound, a plaster cast is applied. This must cover the head, neck, shoulders, and most of the thorax. It should be applied carefully and should be padded carefully, but not too heavily. Openings should be made for the ears, as well as for the face. Various other types of fixation have been used; these usually have been plaster shells, made before operation, and metal and leather splints. Their use has the advantage of shortening the time on the operating table, but neither can be made to fit as accurately or as satisfactorily as the cast which is applied carefully at the end of the operation.

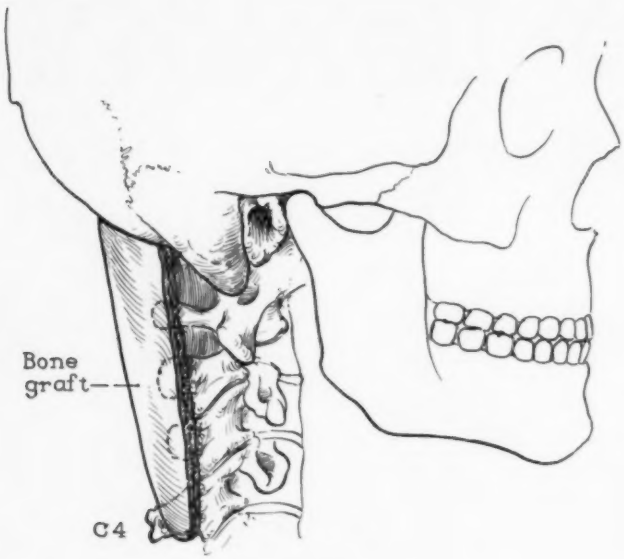

FIG. 6

Diagram illustrating the position of the bone graft. The length of the graft and the close contact made with the occipital bone should be noted.

Two weeks after operation, a window is cut in the cast and the sutures are removed through it. Care must be taken to see that the cast is not weakened at this stage. If it is weakened, it should be reinforced to prevent breaking. The cast should be worn for from ten to twelve weeks. After its removal a metal and leather collar is made, and this is worn for an additional three months. If, at the end of three months, roentgenograms show solid union of the grafts in the occipitocervical region, the support may be discontinued. If sufficient union has not taken place, the support should be continued until union is complete.

The following observations were made by the authors while they were developing this extensive combined operation of intracranial nerve section, rhizotomy, and fusion: In one patient the combined operation was performed successfully and the relief of muscle spasm in the neck was satisfactory, but dystonia developed, chiefly in the muscles of the back and trunk. The patient was incapacitated and the operation was made of little or no value.

In another patient, bilateral section of the spinal accessory nerves and unilateral section of the upper three cervical nerves were first performed through an incision posterior to the sternocleidomastoid muscle. The immediate temporary result appeared to be satisfactory, but the patient returned with an extension of symptoms which necessitated the combined operation. The results seemed satisfactory, but before the plaster cast was

FIG. 7

FIG. 8

Fig. 7: Results accomplished in permanently correcting the subluxation by use of a bone graft. (Same patient as shown in Figs. 1-A and 1-B.)

Fig. 8: Subluxation of the cervical vertebrae has been prevented by the combined operation, which included section of spinal nerves, rhizotomy of cervical nerves, and fusion. Roentgenogram taken three years after operation.

applied to the head, neck, and trunk, symptoms of pressure on the medulla suddenly developed and the patient died. Her death undoubtedly was due to slipping of the bone graft. This prompted a change in the technique so that at present, longer, double bone grafts are used, which are more thoroughly fixed to the occipital bone by heavier silver wire.

In another case, the authors ligated a rather large intervertebral artery which followed the second cervical nerve, believing the adequate blood supply to that portion of the cord came from the dorsal and anterior spinal arteries. Unilateral pyramidal signs developed after the operation and subsequently the patient died. This patient did not have a bone graft, but did have the extensive operation of section of the spinal accessory nerves and rhizotomy of the cervical nerves.

In still another case, respiratory difficulty was encountered when the fourth cervical motor roots on both sides were included in order to denervate the splenius muscle thoroughly. Pneumonia developed, and the patient succumbed.

Another patient was relieved of spasm following the major nerve operations, but was compelled to wear a brace until a graft was introduced, which resulted in adequate fusion, corrected the deformity, and eliminated the necessity of wearing a collar (Fig. 7).

One patient required additional surgery. The first operation was performed on November 27, 1942, at which time bilateral rhizotomy of the upper three cervical nerves, with an intraspinal section of the spinal accessory nerves at the level of the first cervical nerves, was combined with a fusion operation. Unfortunately, certain spasms and contractures still remained, so it became necessary to section the cervical nerves in the neck on the mesial side of the sternocleidomastoid muscles, and to perform myomectomy of the sternocleidomastoid muscle on the right side to relieve the contractures in this muscle. This man has been observed from time to time and the ultimate result is extremely satisfactory (Fig. 8). The time interval from the original operation to the last interview was three years.

COMMENT

In view of late results in the two cases just mentioned, the authors believe that the combined operation—bilateral intracranial section of the spinal accessory nerves and bilateral rhizotomy of the upper three cervical nerves, particularly the anterior roots, with the introduction of a bone graft at the same operation—is indicated for patients with marked muscle spasm on both sides, who are compelled to do manual labor, and for those who have large heads. The major operation on the nerves can be employed without a bone graft for patients whose occupations do not require manual labor. If difficulty in the forward tilting of the head should occur, with impairment in breathing, swallowing, or speaking, a subsequent operation for fusion could be performed. This combined operation of section of nerves and fusion of bone is a major procedure, and should only be employed when the patient is incapacitated as the result of spasmodic torticollis.

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INTRAMEDULLARY PINNING OF DIAPHYSEAL FRACTURES

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TRANSLATED FROM THE FRENCH BY JOHN G. KUHNS, M.D., BOSTON, MASSACHUSETTS

HISTORICAL BACKGROUND

Lambotte has practised the axial method of osteosynthesis of the clavicle since 1907. In 1910, at the *Société Belge de Chirurgie*, he presented a communication on the use of longitudinal screws in fractures with displacement. Later he substituted a carpenter's nail for the screw, because the head of the screw made a projection under the skin; and he is actually using a non-oxidizable nail with a groove. About the same time he accomplished the longitudinal fixation of subtrochanteric fractures by means of a screw, thirteen centimeters long. Much later he applied osteosynthesis by a transarticular approach, and also subcutaneously in transverse fractures of the phalanges (1924), in fractures of the metacarpals, of the upper end of the humerus, and of the lower end of the radius and ulna.

Since 1935, Joly has advocated axial transfixion, sometimes by open and sometimes by closed methods, in a large number of fractures,—of the clavicle, metacarpals, phalanges, toes, carpal scaphoid, malleoli, and rarely of the head of the humerus. He used a Kirschner wire as the material implanted. Danis extolled the use of Kirschner wire to maintain the long axis of the bones of the forearm and of the lower third of the fibula in malleolar fractures.

This great Belgian contribution of an original method of osteosynthesis did not seem to arouse in foreign countries the interest which it merited. Without examining the reasons for this lack of interest, we give several examples.

In America, in 1937 and in 1939, L. V. Rush and H. L. Rush presented as entirely new a technique of longitudinal fixation of the fragments of the superior extremity of the ulna or of the femur, by means of a Steinmann pin. In their method the pin projected from the skin; this prosthesis was temporary,—that is, after a few weeks it was extracted.

In England, Lambrinudi in 1940 presented as a discovery the intramedullary use of Kirschner wires. "The use of intramedullary wires in the treatment of fractures has, so far as I know, not previously been described", he wrote. He referred to three cases in which it was used,—two of the forearm and one of the femur. He also lets the wire protrude through the skin, and removes it between the fourth and fifth weeks. His idea, if we may judge from the comment of disapproval by Watson-Jones in his treatise of 1943, did not seem to have a very successful reception.

The various procedures of osteosynthesis to which we have referred secured longitudinal fixation by a screw, a nail, a wire, or a pin, which traversed the two fragments for a certain distance, following the long axis of the limb, and, when necessary, crossed one or even two adjoining articulations. The fixation material might be in the cortex or might lie obliquely.

The essential characteristic of none of these interventions is intramedullary, properly speaking.

Following the work of Albee, of Cornioley, of Neuman, and of others, osteosynthesis of the long bones by means of bone grafts, living or dead, was advocated. At times small bits of resorbable material were introduced into the medullary cavity at the site of fracture, and they played the role of a bolt or of a pin between the fragments. These procedures had nothing in common with the implantation of metal fixation which we are now describing.

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It was Küntscher who showed convincingly that osteosynthesis could be secured along the medullary cavity of the long bones. His first paper was presented in March 1940 to the *Deutsche Kongress für Chirurgie*. He described longitudinal fixation by means of metallic material, occupying the full length of the medullary space. The material was strong,—a rod of as large size as the bone canal permitted. The material was introduced by an extra-articular route, as far from the fracture site as possible, and without exposure of the fracture. The material was completely buried. The end of the prosthesis which extended beyond the bone was covered by the soft parts and the skin. The reduction had been attained by external manoeuvres before the intramedullary fixation. After consolidation of the bone, the prosthesis was extracted. Thanks to the adaptability of the material and to the technical skill which Küntscher displayed at the outset, one of the most difficult problems of osteosynthesis was solved,—the diaphyseal fracture of the femur. All previous operators by the longitudinal route had only dared to operate upon the superficial bone, the short bones, or fractures at the extremities of bones.

The first communication on this method was not well received; it was called an "antiphysiological method"! In spite of the theoretical criticisms brought against it, the method had a growing vogue in the Central European countries. The early results of many surgeons appeared to be conclusive; the statistics were ample, the published reports were numerous, as shown by the references in our bibliography.

In France, attention was attracted to this method by its use in the victims of enforced labor, men wounded in Germany, where they were operated upon. When these men returned to France, they asked their surgeons to remove the prostheses. (See the communication of Mondor and Nardi on this subject, presented to the *Académie de Chirurgie* in 1942.) Later appeared the fruitful essays of Christian Rocher, of Jeanneney and Magendie of Bordeaux, those of Leveuf, and of Michel-Brechet and Godart of Paris (1944).

In the Scandinavian countries, knowledge of the procedure was widely spread by Westerborn in 1944.

In Belgium, we ourselves have been working on this problem for two years; our first operation was performed June 1, 1943 (Fig. 5-B). Our actual experience with this method was secured from a total of fifty-five operations.

OBJECTIONS TO THE METHOD

The chief objection to medullary pinning is the destruction of the bone marrow. The lesions produced blindly might lead to unpleasant sequelae. This apprehension was voiced at the first exposition of the technique in 1940; various surgeons asked this question in our hearing. Even if the prosthesis should destroy all of the medullary contents, which is scarcely probable, we know very well that the individual is easily able to do without the hematopoietic element in one of the long bones. Patients who have had amputations which entailed the loss of the larger segments of a limb never show evidence of the loss of bone marrow in the histological examination of the blood. Also in curettage for osteomyelitis and in bone-grafting, there is at times serious destruction of the bone marrow.

Slany, in 1944, studied the blood of patients subjected to medullary pinning. After this intervention he noted an increase in the number of reticulocytes, the presence of young leukocytic forms, eosinophils in infants and adolescents, and finally in certain individuals an anaemia,—a diminution in the number of red cells and in the hemoglobin. After the removal of the prosthesis, the return to the normal blood picture was rapid. Since fractures of the long bones, regardless of the method of treatment used, have a tendency to provoke manifestations in the blood similar to those which appear with this treatment, and since the symptoms are mild, the problem may be of interest to the hematologist, but is of little concern to the surgeon. It is better to remove the material, when it is possible to do so.

The risk of fat embolism is a more important consideration. Concerning this matter, it is the practice, not the theory, which gives the answer. Statistics of more than a hundred

fixations, which have been published, affirm that the method does not expose to the danger of embolism. We have watched our patients who have been operated upon most particularly in this matter; and we can verify this statement. In more than fifty osteosyntheses by the intramedullary method, only once have we seen postoperative pulmonary embolism.

This was in a patient of thirty-four years, who presented a spiral fracture of the middle third of the femur. Three days after the accident, the bone was pinned after closed reduction. Operation was easy and there was no shock. Forty-eight hours later pain, increased by deep breathing, was found at a point under the ribs on the left side. The heart beat was regular, the pulse twenty-two beats to the quarter. Râles were heard at the left base. The following day the temperature was 39 degrees centigrade, and there was slight hemoptysis. On subsequent days there was gradual subsidence of the fever. On the seventh day there was no fever, and his condition had returned to normal. This patient was operated upon more than a month ago and is included in the group here presented.

It is apparent that only experience on a vast scale will be able to answer definitely the question concerning the danger of embolism. At present, the risk appears to be slight.

The possibilities of operative infection are present, as in all surgical procedures, particularly in operations upon the bones. In our opinion, the septic complications—all other factors being equal—are less to be feared after medullary pinning than following other methods of osteosynthesis. There is little trauma, and the method entails less disturbance of the muscles and manipulation of the fragments than occurs with open procedures. The few suppurations which we have seen followed osteosynthesis in compound fractures, a type of fracture in which the method is contra-indicated. In any case, we have learned that the presence of a foreign body in the medullary cavity does not in itself constitute a predisposition to infection. Osteomyelitis in the entire diaphysis need not be feared, even when the operative site becomes infected.

MERITS OF THE METHOD

1. The operation causes little shock. Medullary osteosynthesis is a safe intervention. The incision is short; there is little hemorrhage; bleeding is reduced to a minimum, since the site of the fracture is not often opened. The postoperative well-being and the objective state of the patient are truly astounding, and they remain so in the days that follow.

2. The prosthesis is simple. The bloodless reduction of the fracture without doubt requires dexterity on the part of the surgeon, and is tedious, because of roentgenographic control and successive corrections. It is a stage of the operation which is unimportant to the patient, since the operation is performed under spinal or local anaesthesia. When end-to-end apposition has been obtained, the insertion of the prosthesis is easy, for it does not require particular manual dexterity. With the pin in place, the operation is practically finished. If it is necessary to perform an open reduction, operative reduction of the fracture is all that is required, usually easy in fresh fractures. The problem of osteosynthesis is thus simplified. In other methods of osteosynthesis, the difficulties arise in the fixation after reduction; this requires not only exposure of the site of the fracture for reduction, but also wide exposure. It is essential to maintain the coaptation of the fragments during the time the bed is prepared for the prosthesis, during the fitting, and while fixing it in place.

3. Formation of callus is rapid. Our observations verify those of others. The callus forms more quickly when medullary metallic fixation is employed than with any other method. After three weeks usually, periosteal calcification is readily seen in roentgenograms of a diaphyseal fracture of the femur. The exactness of the reduction, the possibility of axial impaction, the active mobilization of the limb,—all these do not in themselves explain the excitation of periosteal osteogenesis.

It may well be that the presence of a foreign body in the medullary canal is responsible for this. Küntscher introduced steel wires (V-2A) into the intact diaphyses of long

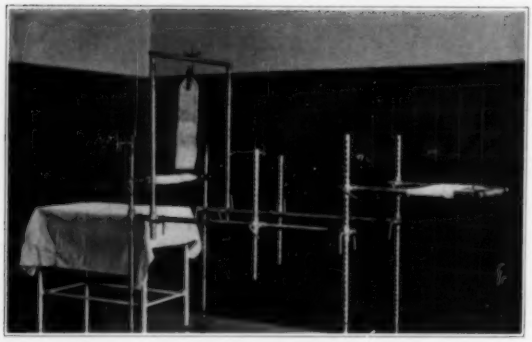

FIG. 1

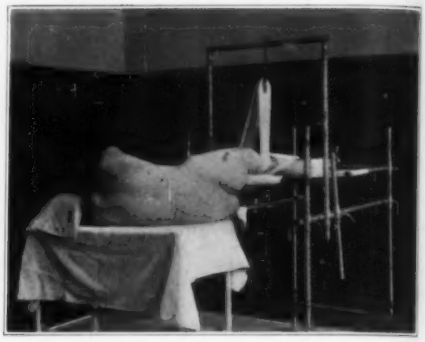

FIG. 2

Fig. 1: The author's apparatus, based on the same principle as the Böhler frame. It stands directly on the floor, not on a table. It is very large in order to permit better traction upward (by the sling) and anteriorly and posteriorly (by the traction screw).

Fig. 2: Apparatus at right angle to the operating table. Patient in position.

bones of dogs. A few weeks following this procedure, he observed thickening and calcification of the periosteum. The appearance was similar to the ossification seen in sarcoma. We do not know how to interpret these observations. Is that which takes place a defense reaction of bony tissue, comparable to that which takes place when there is a central sequestrum, or does the periosteum react to central pressure on the bone? Examination of our patients leads us to favor the second hypothesis. The hypertrophy of the callus is more intense whenever we use a thick prosthesis. It is less intense whenever the material is very thin (as Kirschner wire).

Whatever its cause may be, this tendency to exuberance of the bony cicatrix is a welcome result to the surgeon, since it takes place in fractures at the locations where he dreads pseudarthroses. Another consequence of this hypertrophy of callus is the necessity of removing the prosthesis after definite consolidation of the fracture.

4. Early mobilization is possible. Because there is no pain, because callus forms rapidly, and because the parts of the limb are firmly fixed, motion is resumed quickly. Active mobilization begins from the first days following operation. Patients with operations upon the thigh usually walk about with two canes by the sixth week. Those with operations upon the leg get about by the twelfth day. Patients with operations upon the upper arm are able to contract the deltoid muscle (Fig. 13-B); with operations upon the forearm, they can move the fingers. Massage and other forms of physiotherapy are generally superfluous, since the joints maintain their suppleness, the muscles their tonus, and the circulation its normal course. The period of hospitalization is greatly reduced, in comparison with that required by other methods of treatment, notably continuous extension.

THE FEMUR

If possible, femoral fractures are reduced under roentgenographic control by manipulation; if not, the fracture is exposed and the fragments are replaced under direct vision. The nail enters the medullary cavity by the supratrochanteric route. It traverses the entire length of the diaphysis; below, it is imbedded in the spongy tissue of the lower epiphysis. As a general rule, a plaster cast is unnecessary. The patient moves the limb during the first days after operation, and he is allowed to get up early.

Choice of Pin

During the German occupation of Belgium, it was impossible to procure the original material used, which consisted of pins having one section approximately in the form of a V. We were satisfied with U-shaped pins made from cylindrical bars of non-oxidizing steel

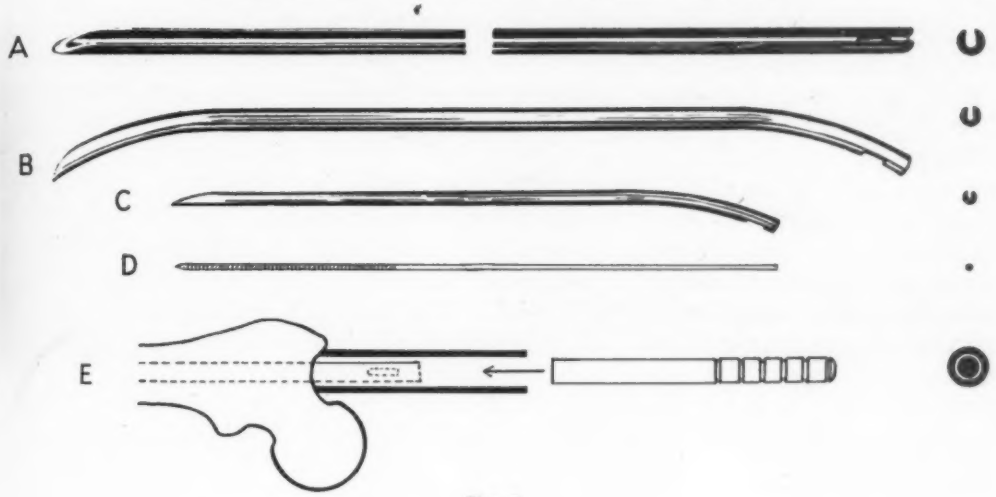

FIG. 3

Prostheses and Pin Driver

A: Straight pin of grooved bar of steel (V-2A). One end is pointed, the other shows a small eye. In profile these pins are in the form of a U. For a femoral diaphysis, the diameter of the pin is usually eight millimeters. The thickness of the sides of the U is two millimeters. For the humerus and the ulna the pins are similar, but shorter and thinner.

B: Tibial pin, made of the same material as the straight pin, and six to eight millimeters in diameter. It is curved at both ends. The point of the curve is generally 1.5 centimeters from the end.

C: Radial pin, five millimeters in diameter. It has a single curve.

D: Threaded rod for the ulna and radius, two to three millimeters in diameter.

E: Graduated pin driver. The guiding tube has been slid over the pin up to the bone. The mandril will be introduced into the tube. The graduations on the mandril show the extent to which the pin penetrates the bone.

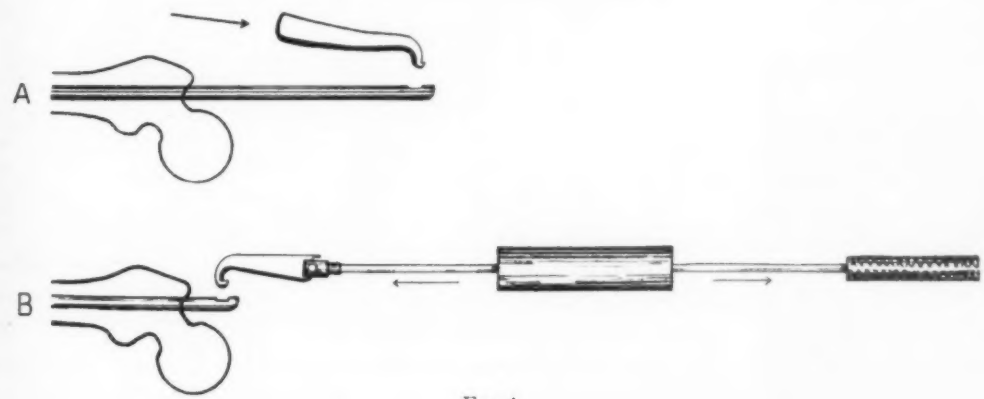

FIG. 4

Extractor

A: The instrument is eighteen centimeters long. A hook fits into the eyelet of the pin. By blows with the tip of the hammer, one frees the prosthesis. This instrument is useful in the operation when it is necessary to retract the pin in order to change its direction.

B: Hammer-extractor permits the freeing of a pin when the head of the pin alone is accessible (after consolidation). The rod, thirty-five centimeters long, has a hook attached to one end and a handle to the other. A metallic mass, weighing one kilogram, moves freely on the rod. While the assistant holds the handle, the surgeon drives the mass violently against the handle.

(V-2A). As to the thickness of the pin, it should be quite exact. If the pin is too thick, it may split the cortex; if too thin, there is a tendency for the fragments to play. It would seem important in each case to study the size of the medullary cavity from the roentgenograms; in practice, this thesis proves to be erroneous. The medullary cavity is not rectilinear; in the femur it is curved in two planes.

Our pin is straight. It acts efficiently, because it is wedged into an irregular canal, the walls of which it touches, sometimes one wall, sometimes the other. It traverses the entire length of the femur. The forces which are exerted are divided along a great distance of material. In this it differs from osteosynthesis with plates or bars, in which the prosthesis, very short, receives practically all the force of flexion or of torsion at one point. In practice, with adults we use pins less than nine millimeters in diameter.

The length of the pin should be determined before operation. Here again roentgenographic data seem superfluous, and may be the cause of error. The procedure is very simple; on the skin we measure the femur on the sound side, taking the distance from the top of the greater trochanter to the knee-joint line. From this measurement we subtract a constant figure, four centimeters; in this way we obtain a satisfactory approximation, whatever the size of the muscles may be. With roentgenographic control, we can judge how deeply the pin should be placed. The head of the pin may project level with the trochanter or, without inconvenience, it may project beyond it for three centimeters.

Position of the Patient

The ordinary orthopaedic table is not suitable. We use a Böhler frame for fractures of the lower extremity or a larger frame based on the same principles (Figs. 1 and 2). The patient is placed in lateral decubitus on the sound side. The trunk is flexed to a right angle with the thigh. In this position, access to the trochanteric region is easy.

Reduction

We operate under spinal anaesthesia. Traction is applied in the axis of the limb with a foot hitch. Overriding is reduced; and coaptation is secured by lateral straps. Verification of reduction is made by anteroposterior and lateral roentgenograms. (We have given up fluoroscopy, which presents a number of disadvantages. It is technically difficult to view the fracture through the screen and to operate at the same time. Fluoroscopy gives inexact information, and there is danger of radiodermatitis.) The reduction should be anatomical. The pin cannot be introduced if the medullary cavity has not regained its contour. Thus in fractures impossible to reduce, such as comminuted fractures and old fractures, it is necessary to expose the site of fracture. After an external, longitudinal incision, the fragments can be replaced easily. This does not require the wide exposure necessary in osteosynthesis by plates or screws.

FIG. 5-A

Transverse fracture of the middle third of the femur. The patient, aged forty-nine, was injured in an accident on May 24, 1943. This was the first patient operated upon.

Introduction of the Pin

Through an incision of eight to ten centimeters in the supratrochanteric region (Fig. 2), the superior surface of the greater trochanter is reached, after retraction of the muscles. The point of introduction is not at the top of the trochanter, but at the junction of that prominence and the femoral neck, which is exactly at the prolongation of the medullary cavity. The cortex is trephined with a gouge. A guide is then introduced. This is a steel wire, three millimeters in diameter and forty centimeters long. Either by roentgenogram or, in an open reduction, by direct view, verification is made of the presence of the guide in the medullary cavity.

Osteosynthesis

The pin is slid along the guide and is driven into the medullary cavity by hammer blows. The guide is then removed. New roentgenograms show the position of the pin, its introduction into the distal fragment, and finally its

depth. It should reach the lower epiphysis, but should not perforate the knee joint. If, by accident, the prosthesis fails to enter the distal fragment, passing to the side, it must be extracted and replaced after any angulation has been corrected. The final suture of the wound presents no particular problem.

FIG. 5-B

FIG. 5-C

FIG. 5-D

Fig. 5-B: On June 1, 1943, osteosynthesis was performed under spinal anaesthesia. Closed reduction was accomplished in the lateral position on the Böhler frame, with the aid of the fluoroscope. By supratrochanteric incision and after trephining at the junction of the trochanter and the femoral neck, a straight pin, thirty-eight centimeters long and nine millimeters thick, was inserted. Walking was permitted by August 6.

Figs. 5-C and 5-D: Roentgenograms, taken January 21, 1944, showed solid union without shortening or angulation. The pin had been removed on November 22, 1943. There was perfect function. The patient returned to work four months after operation.

Postoperative Care

The limb is placed on a Braun frame. After the second day the patient may move his foot, and a little later the knee and the hip. After the joints have regained their normal range of motion, the patient is allowed up. Usually about the fifth or sixth week, he is able to walk with canes, and then without any support. Roentgenograms are taken to determine the degree of bony union.

Removal of the Prosthesis

Between the third and sixth months it is necessary to withdraw the prosthesis. For this a special extractor is necessary (Fig. 4). Pincers of the usual type and extractors of the Smith-Petersen type are of no avail. Not by strong traction alone can a well-fixed medullary pin be freed, for it was fixed in place by strong friction and by hammer blows. Only by a series of blows applied in the opposite direction in the axis of the bone is it possible to remove it. We use an instrument suggested by one that Stör described; it is very strong and it catches in the eye fashioned in the end of the prosthesis. To neglect the use of such an extractor is to court failure; upon this point we cannot insist too strongly.

Results

1. *Simple Fractures of the Upper and of the Middle Thirds of the Femur*: We encountered eight fractures in patients between the ages of seventeen and fifty-four years. Four of these were treated without the site of fracture being exposed; four were reduced by open operation. With the exception of those who presented other lesions, such as fracture of the pelvis, fracture of the leg, *et cetera*, all were walking easily between the first and second months. The pins were removed between the fourth and the seventh months. All of these fractures healed without shortening and without displacement, without muscle atrophy and without infection (Figs. 6-A, 6-B, and 6-C). We believe that these results are from all points of view much better than those obtained by continuous extension.

2. *Simple Fractures of the Lower Third*: The nearer to the knee is the site of the fracture, the less efficient is the fixation. It is necessary to anticipate the possibility of displacement of the distal fragment by rotation. To prevent this displacement after operation, we apply a large plaster cast, including the pelvis and foot. We have operated upon two fractures at the upper part of the lower third of the femur. In one case the result was satisfactory, although there was slight angulation because of the poor quality of the prosthesis; and in the other the result was difficult to evaluate. This was the case of a boy of sixteen; the fracture healed in the normal manner and the pin was removed in the fifth month. The boy walked normally and had returned to work. He fell again and fractured the femur at the same level. Following immobilization in plaster, the fracture healed with shortening of two centimeters. It is difficult to say whether the new fracture was caused by poor callus or by the second accident. (We have not treated by this method any fracture at the distal fourth of the femur.)

FIG. 6-A

Comminuted fracture of the middle third of the femur. The patient, aged seventeen years, had an accident on January 15, 1945. Osteosynthesis was performed on January 27, with spinal anaesthesia, traction, and open reduction. The fragments were held in position by a pin, forty centimeters long, inserted by a trochanteric route.

3. In *compound fractures* the results were poor. One fracture, resulting in three fragments and associated with an extensive wound of the soft parts, was operated upon a few hours after the accident; the patient died during the operation. In two compound fractures with minimum wounds, operation was delayed until the wounds appeared healed. Infection appeared in the two cases and was clearly connected with the original wounds.

FIG. 6-B FIG. 6-C

Fig. 6-B: Roentgenograms made April 6, 1945, showed good reduction with massive callus.

Fig. 6-C: Follow-up roentgenograms, made July 3, 1945. The pin had been removed fifteen days before, five months after the reduction. The functional result was perfect.

4. *Pseudarthroses*: Two patients with old pseudarthroses had undergone varied treatments (extension, osteosynthesis, plaster fixation). Both were operated upon. Good consolidation occurred in one case (Figs. 8-A and 8-B); failure resulted in the other through an error in technique.

5. *Shortening*: An excellent result in equalization of the limbs was obtained in one case. This woman, twenty-seven years old, had a shortening from congenital dislocation of the hip. Five centimeters was removed from the normal femur and this was followed by intramedullary pinning and the application of a plaster cast. Union was complete and the result was perfect after four and one-half months.

6. *Pathological Fractures*: The criterion of "cure" is much more difficult to determine in such cases. A tabetic, fifty-two years old, presented a fracture of the upper third

FIG. 7-A

FIG. 7-B

FIG. 7-C

Fig. 7-A: Comminuted fracture of the middle third of the left femur in a patient twenty-three years old. Osteosynthesis was performed September 16, 1944, under spinal anaesthesia. Traction was applied, with the patient on the Böhler frame; then open reduction and intramedullary pinning were done. A long plaster spica was applied for six weeks to prevent rotation.

Fig. 7-B: Roentgenograms made on October 30, 1944, forty-four days after operation. The patient was out of bed.

Fig. 7-C: Showing final result on May 15, 1945. A massive callus was palpable. The functional condition was perfect, without muscle atrophy or limitation of motion. The prosthesis had been removed four months after operation.

Fig. 8-A: Pseudarthrosis of the femur. Patient, sixty years old, was injured February 5, 1943; had already been subjected to osteosynthesis by bolts when admitted. Traction was continued, with plaster from pelvis to foot, without any change. The knee was ankylosed. Roentgenogram shows the pre-operative state. Eight months after the accident, on October 7, 1943, we did an intramedullary pinning.

Fig. 8-B: Roentgenograms on June 13, 1944, showed consolidated pseudarthrosis and markedly exuberant callus. The prosthesis used was very thin. Slight flexion occurred at the fracture site. Note also that calcification was produced about the end of the pin. In order to remove the prosthesis, it was necessary to break this bony covering with a blow of the hammer.

When last seen, on January 15, 1945, there was perfect consolidation. Patient walked without a cane, with heel raised three centimeters. Hip had 45 degrees of flexion, 30 degrees of abduction. Knee flexion was 50 degrees.

FIG. 8-A

FIG. 8-B

of the femur, which healed perfectly. Two patients, sixty-two and seventy-three years old, respectively, with Paget's disease, with old pseudarthroses, and in very poor general condition, were treated by this method. One had good union; the other died on the twenty-third day. Two senile patients with spontaneous fractures, which occurred in bed, were operated upon. One, eighty years old, died on the fourth day. The other, seventy-three years old, had a normal postoperative course and died from apoplexy two months later. Two patients with inoperable tumors and spontaneous fractures were operated upon. One survived for one month. This patient was sixty-nine, with bone metastases of an epithelioma. The other, with multiple myeloma, survived for four months. It is evident that our attempts in these seven hopeless cases seemed to lessen their pain and, in five of the patients, made the nursing care easier.

Indications

From a total of twenty-three diaphyseal fractures of the femur, we are able to draw the following conclusions: Intramedullary osteosynthesis gives excellent results in closed fractures, particularly those in the upper third, in the middle third, and in the upper portion of the lower third. It is indicated in pseudarthrosis and in shortening of one femur for equalization of the limbs. It is of value in pathological fractures, where it is impossible to apply any other method. We advise against its use in compound fractures.

THE TIBIA

The principles comprise reduction of the fracture on the Böhler frame, the introduction of a bent pin through the anterior tuberosity of the tibia, and the application of an ambulatory plaster from the thigh to the toes.

Choice of Pin

The end of the pin is in the form of a V or a U. It is slightly curved. Its diameter is six to eight millimeters, depending upon the skeleton of the patient. For determination of

Fig. 7-C: Showing final result on May 15, 1945. A massive callus was palpable. The functional condition was perfect, without muscle atrophy or limitation of motion. The prosthesis had been removed four months after operation.

FIG. 9-A

FIG. 9-B

Fig. 9-A: Diaphyseal fractures of both bones of the leg. The patient, thirty years old, was injured January 1, 1944, by torsion. On January 7, closed reduction and pinning were done under spinal anaesthesia, with the patient on the Böhler frame.

Fig. 9-B: Showing result immediately after osteosynthesis. Patient was in ambulatory plaster for six weeks.

its length, the distance between the medial joint line of the knee and the tip of the medial malleolus is measured. From this length is subtracted four centimeters, or three centimeters if the fracture is situated very low.

Position of the Patient

The position used is that which Böhler described for the closed reduction of fractures of the leg. The knee is flexed markedly upon the special frame. The anterior tuberosity of the tibia is easily accessible. Traction on the foot does not require a Kirschner wire; a hitch suffices.

Reduction

Spinal anaesthesia gives ideal muscle relaxation. By palpation, fluoroscopy, or subsequent roentgenography, the reduction is verified. If it is not perfect the first time, which often occurs with spiral fractures, it may be necessary to expose the fracture site by a short incision, and reduce the fragments.

Introduction of the Pin

By a longitudinal incision, along the tibial crest, the anterior tuberosity is exposed. The point at which the cortex is trephined is immediately above this apophysis, at the

FIG. 9-C

FIG. 9-D

Fig. 9-C: Show result on September 29, 1944, with solid callus. The prosthesis was removed the next day.

Fig. 9-D: Result on May 25, 1945, sixteen months after operation.

insertion of the longest fibers of the patellar tendon. The concavity of the pin is turned forward. The pin is driven by a hammer into the medullary cavity of the proximal fragment.

Osteosynthesis

After the correct location of the pin has been verified by roentgenograms, the prosthesis is driven into the distal fragment, while an assistant maintains rigid reduction with a Lambotte clamp, if the site of fracture has been exposed. A final roentgenogram of the ankle determines the depth of penetration of the pin. The skin only is sutured, and a plaster is applied from mid-thigh to toes.

Postoperative Care

On the tenth day the plaster is removed. The stitches are taken out. A new plaster is applied, which is attached to a Telson patten. The patient is then permitted to get up and to leave the hospital. Walking is easy and painless. The plaster is removed after the roentgenograms show the formation of callus, usually about the seventh or eighth week. A bandage of Unna's paste prevents subsequent oedema.

Removal of the Prosthesis

The pin is removed between the third and fifth months. The extractor is indispensable.

Results

Ten patients, all adults (between thirty and sixty years of age), have been operated upon (Figs. 9-A, 9-B, 9-C, and 9-D). With the exception of one case in which the fracture was in the upper third of the leg, all of the fractures were spiral or comminuted and were at about the junction of the middle and lower thirds. We have had no opportunity to operate upon transverse fractures of the middle third. In two patients closed reduction sufficed; in eight, open operations were performed. At first, believing the osteosynthesis solid, we applied no plaster cast. The patients walked very early, with no support on the leg. The results were not satisfactory. Of five patients treated in this manner, three had perfect consolidation and two had pseudarthroses. Pseudarthrosis did not appear for a number of weeks after operation; the distal fragment with the foot turned, little by little, into external rotation. We have had to deal with fractures located near the distal end. Subsequently we adopted the method of applying an ambulatory plaster, as mentioned before. Five patients, treated in this way, obtained perfect union with no shortening and no angulation, complete function without muscle atrophy, and without the need of physiotherapy. In one case we used two pins, as certain writers advise, but this did not seem to give a better result.

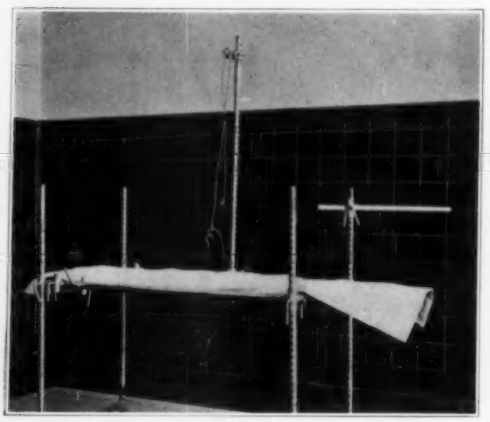

FIG. 10

The author's apparatus for reduction of fractures of the femur (Fig. 1) can be used also for pinning of the humerus. A board has been placed horizontally. One bar, 1.5 meters high, is used for traction, another to support the hand.

Indications

Medullary pinning with a curved pin, in fractures situated at the junction of the middle and lower thirds of the tibia, gave excellent results, provided that an ambulatory plaster was applied. If we compare our results with those which we obtained previously by closed methods (reduction on a Böhler frame, extension with a Steinmann pin in the calcaneus, and plaster for four to five weeks, then ambulatory plaster for six to ten weeks), we find the following advantages in favor of pinning: anatomical reduction, rapid consolidation, shortening of the period of hospitalization, better functional recuperation, since there is no atrophy of the quadriceps. One disadvantage of pinning is the presence of an operative scar, which is objected to by young girls for aesthetic reasons. This method is certainly indicated in fractures of the middle and upper thirds. Our experience does not permit us to say whether or not a plaster cast is necessary in such cases. The method is not recommended in compound fractures. For pseudarthrosis we prefer a bone graft.

THE HUMERUS

At first we introduced a curved pin by way of the olecranon fossa. We have discontinued this. We prefer the upper route, driving a straight pin into the head of the humerus, toward the elbow. We shall describe only the latter technique.

Choice of Pin

A straight pin is used, grooved in the form of a U and five to seven millimeters in diameter. The length is determined beforehand by the following method: On the sound side the distance between the lateral tip of the acromion and the olecranon is measured with the arm at the side, the elbow flexed to 90 degrees. From the figure obtained, five centimeters is subtracted.

Position of the Patient

It is impossible to reach the humeral head unless it is brought into prominence. For this, the arm should be put in flexion and in strong adduction. The patient is in lateral decubitus on the sound side. The injured arm is fixed snugly on the thorax in maximum flexion (Fig. 11).

Introduction of the Pin

In contrast with other bones, medullary pinning of the humerus is started *before* reduction. The operation is begun under brachial plexus anaesthesia, with local anaesthesia of the skin of the shoulder. A Kirschner wire is passed through the upper part of the ulna, and a stirrup is attached. In this way, skeletal traction is attained. The patient is placed in the position indicated in the preceding paragraph (Figs. 10 and 11). Where the humeral head is most accessible, a short longitudinal incision is made. The fibers of the deltoid are retracted, and the point where the tuberosity joins the anatomical neck is marked. This is the point of penetration. With a gouge, the bone is trephined. During this manoeuvre the articular capsule may be opened slightly. Through the hole in the humeral head, the guide (a steel wire, three millimeters in diameter and forty centimeters long) is forced into the medullary cavity. Roentgenograms verify the position of the guide. The pin is driven along the guide into the proximal fragment only. The guide is then removed. The situation is then the following: The fracture has not been reduced, the pin is in the proximal fragment, and a large part of it projects. (At this point, the segment of the pin which protrudes and the operative site must be well protected with sterile dressings.)

Reduction

The patient is placed in dorsal decubitus and attached to the table with straps. With a pulley, placed 1.5 meters above the level of the table and on the side opposite the fracture, progressive extension is applied through the Kirschner apparatus. The arm should be in at least 45 degrees of adduction and 75 degrees of elevation (Fig. 12). The

FIG. 11

FIG. 12

Fig. 11: Diaphyseal fracture of the humerus—first step in treatment. Brachial plexus anaesthesia with patient in lateral decubitus on the sound side. Arm is in adduction and extreme flexion. Kirschner traction at the level of the ulna. In this position the humeral head is easily accessible; it forms a projection. Shows incision and placing of the pin in the proximal fragment.

Fig. 12: Second step: Reduction of the fracture, with patient in dorsal decubitus; traction, with the arm at 75 degrees of elevation and 45 degrees of adduction; elbow at right angle. Fluoroscope or roentgenograms may be used. Open operation is easy, if required. The pin, which is yet only in the proximal fragment, has been protected by sterile dressings during the moving of the patient.

elbow is flexed to a right angle. Reduction is checked by fluoroscope or by roentgenogram. Angulation is corrected by lateral slings. If anatomical reduction cannot be obtained, it may be necessary to expose the site of fracture by one of the classical incisions,—along the deltopectoral groove for the upper third, the external or internal border of the biceps for the middle third, the posterior surface of the arm for the lower third.

Osteosynthesis

The introduction of the pin into the distal fragment is simple after reduction has been obtained. It is sufficient to remove the sterile compresses and to strike a few hammer blows upon the head of the pin. At the end of the operation, the pin should not project more than five millimeters from the humerus; otherwise, it will impinge on the acromion in movements of the shoulder. After suture of the wound and removal of the Kirschner wire, no plaster cast is applied, except in fractures in the lower part of the humerus.

Postoperative Care

The fingers, the elbow, and the shoulder are moved at once. The patient is allowed up the day following operation.

Removal of the Prosthesis

The pin is removed two to four months after the osteosynthesis.

FIG. 13-A

FIG. 13-B

Fig. 13-A: A woman of forty-eight fell in the snow and incurred an oblique fracture of the middle third of the humerus. Six days after the accident, on January 3, 1945, osteosynthesis was done, with brachial plexus anaesthesia, traction, closed reduction by roentgenographic control, incision, and trephining at the level of the olecranon fossa. Fixation was accomplished by a Kirschner wire as a guide, then by a medullary pin.

Fig. 13-B: Movement was begun at once. Photograph was taken on January 30, 1945, less than four weeks after operation.

FIG. 13-C

FIG. 13-D

Fig. 13-C: Six weeks after operation (February 6), solid callus was present. The guide had been left in place. The pin was removed in the third month. The functional result (end of May 1945) was very satisfactory. Abduction of the shoulder was practically normal. Elbow had complete flexion, extension of 170 degrees.

Fig. 13-D: Osteosynthesis of the humerus by the upper route in a woman eighty years old with radial paralysis. A straight pin, six millimeters in diameter, was introduced in the region of the humeral head. Below, it reached the inferior epiphysis. Operation was performed June 13, 1945. Control roentgenograms taken July 2, 1945, showed early callus. Patient is under constant treatment. She can use the hand and elbow easily. Active abduction of the arm exceeds 90 degrees. She exercises by means of a pulley.

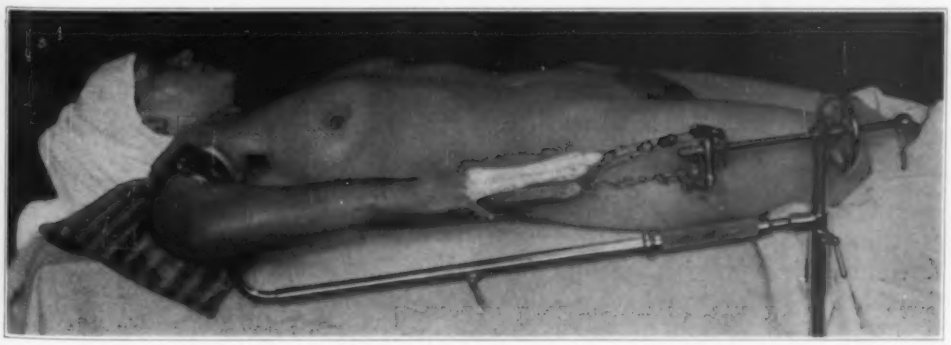

FIG. 14

The author's apparatus for osteosynthesis of fractures of the forearm and closed reduction of fractures of the thumb and dislocations of the carpal bones. Traction by finger cots with plaited strands. Counterextension by an arm cuff. Note the cushion under the arm. Photograph taken at the conclusion of pinning of the radius at the junction of the middle and lower thirds; brachial plexus anaesthesia was used. In this case the incision used to reduce the fracture joined that which permitted introduction of the prosthesis.

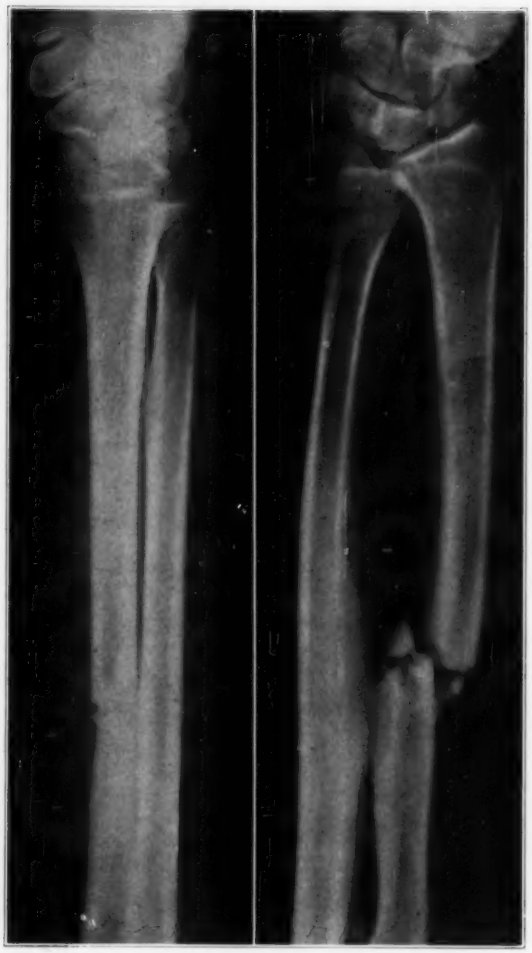

FIG. 15-A

FIG. 15-B

Fig. 15-A: Transverse fracture of the radius alone, in a man of seventy-one years, who had been a victim of bombardment on May 9, 1944. Attempts at closed reduction failed. On May 19, 1944, under brachial plexus anaesthesia, traction by the author's apparatus (see Fig. 14) and open reduction were done, with trephining of the radius from the dorsal surface of the lower epiphysis. A curved pin, five millimeters in diameter, was inserted. No plaster was used.

Fig. 15-B: Ten days after osteosynthesis we entered the room unexpectedly and saw the patient eating soup, with the spoon in the right hand,—the side operated upon. Roentgenograms, taken on January 3, 1945, showed perfect callus. Grasp was normal. Pronation and supination were 120 degrees. The patient refused permission to remove the prosthesis, which did not trouble him.

Results

We have operated upon nine patients. In the first six, we used the lower route of entry,—that is, a curved pin forced through the olecranon fossa toward the shoulder. The patients ranged in age from fifteen to sixty years. Four had transverse or spiral fractures of the middle third and two had fractures at the junction of the middle and lower thirds (Figs. 13-A, 13-B, and 13-C). In three patients closed reduction sufficed; in three open reduction was required. The following results were obtained: In one patient the pin was placed incorrectly; consequently, the consolidation was due to the reduction and the plaster cast. In spite of the final good result, it was a failure of the method. The five others healed rapidly with solid callus. Movements of the hand and shoulder were perfect. Twice we found a limitation of extension at the elbow, loss of 20 degrees for one and of 25 degrees for the other. Because of this limitation of extension of the elbow and because

of the difficulty of the technique (curved pin and a difficult approach to the humerus by the oleocranon fossa), we have given up the lower approach and now use only the upper approach described above. Of three patients operated upon by the upper approach, one, seventy-five years old, had Paget's disease of the humerus; one, thirty-four years old, had a spiral fracture of the middle third; one, eighty years old, had a transverse fracture at the junction of the middle and lower thirds (Fig. 13-D). Twice open reduction was carried out; in one, closed reduction sufficed. The results are recent, but very good.

Indications

The intramedullary pinning lends itself to all closed fractures of the humeral diaphysis. The upper approach with a straight pin seems preferable to the lower approach with a curved pin.

FOREARM

Open reduction is performed. At the elbow, a pin or a square rod is driven into the ulna by way of the olecranon. For the radius, a slightly curved pin or rod is introduced from the lower epiphysis.

Choice of Pin

The size of the medullary cavity of the bones of the forearm varies greatly in

FIG. 16-A

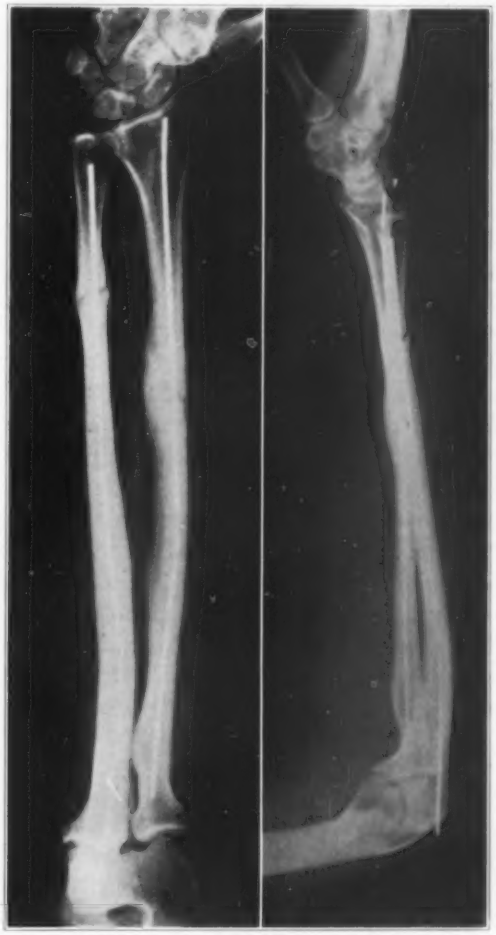

FIG. 16-B

Fig. 16-A: A woman of twenty-five was in an automobile accident on October 5, 1944. Attempt at closed reduction was unsuccessful. On the tenth day, osteosynthesis was performed under brachial plexus anaesthesia, with traction by apparatus, incision over both fracture areas, and reduction. The medullary cavities were extremely narrow and permitted only the passage of fine Kirschner wires. Pinning of the ulna was done by way of the olecranon; pinning of the radius, from the lower end (incision and trephining). Plaster was applied to the forearm for three months.

Fig. 16-B: Control roentgenograms, seven months after operation (May 25, 1945) showed perfect callus. In the lateral view it appeared that the wire passed into the radiocarpal articulation; the anterior view showed that the wire was superimposed; the place of perforation is in reality situated two centimeters higher than the joint line. Functional result was perfect.

patients. The radius of a robust man permits the passage of a pin five millimeters in diameter, while in a small, frail woman, a rod of 1.3 millimeters is as large as can be passed. It is often difficult to judge the size in advance, and roentgenograms are misleading. It is only during operation that one can determine the size. We always place on the table some of the V and U pins of five-millimeter diameter and rods of 1.5 to three millimeters. For these pins the length is easy to determine directly on the injured forearm. For the rods, any estimation beforehand is unnecessary.

Position of the Patient

We always operate with brachial plexus anaesthesia. The limb is placed on a special apparatus, which we devised some time ago, and which we use for closed reductions of fractures of the thumb and dislocations of the carpal bones (Fig. 14). The patient is in dorsal decubitus. The elbow is at a right angle. Traction is applied on the fingers by means of finger stalls with woven fibers. Counterextension is made on the arm, as described by the author in a paper in *Revue d'Orthopedie* in 1941.

Reduction

Experience has shown us that in the forearm, simple traction and manipulation lead to approximate, but not anatomical, reduction. Thus it may be necessary to expose the site of fracture. We follow the classical incisions. Reduction is easily obtained with the use of the periosteal elevator and the Lambotte hook.

Osteosynthesis

In fractures of both bones, we begin always with the ulna. During the open reduction, we examine the size of the medullary cavity and try the prosthesis to determine if we must use a pin or a rod. By a very small incision over the olecranon the prosthesis is introduced, care being taken to direct the pin or rod accurately. A blow of the hammer will drive in a pin of five millimeters or a rod of 2.5 to three millimeters. If a thinner rod is used, a Kirschner perforator will be required. The passing of the pin or rod from one fragment to the other is controlled by observing the fracture site. After roentgenograms have been taken, the wound is sutured. If a rod has been used, which projects from the olecranon, the projecting portion is cut with pincers. The radius is exposed in turn. An incision, five centimeters long, is made on the dorsal surface between the extensor tendons of the thumb and of the index finger. The tendons are retracted and, with a fine gouge, the cortex is trephined. A curved pin or rod is introduced from below upward. After control roentgenograms have been taken, the wound is sutured. In osteosynthesis with a pin, no immobilization is required. With a rod, one must guard against flexion at the site of fracture. A plaster cast of the forearm alone is necessary.

Postoperative Care

Whether or not a plaster is used, movements of the fingers, the elbow, the shoulder, and of pronation and supination are encouraged at once. It is surprising to see how these movements are easily performed and are painless. After ten days, the plaster cast is cut, the sutures are removed, and a new plaster is applied and worn until union is complete.

Removal of the Prosthesis

During the third month the prosthesis is removed.

Results

Thirteen patients, ranging in age from seventeen to seventy-one years, were operated upon. Therapeutically, these cases may be tabulated as follows:

1. In six cases in which pins of five millimeters were used, three were fractures of both bones, two were fractures of the radius in the middle third, and one involved the ulna in the upper third. All of these fractures healed in less than two months. The functional

result was poor in one case with synostosis of the two bones, where there was comminution of the radius and ulna. The results were very good in the other five. Function and strength in the hands were regained, pronation and supination were preserved (Figs. 15-A and 15-B).

2. Two fractures of both bones in the middle third were fixed with rods, 2.3 millimeters in diameter, with perfect results.

3. Three cases (two with fractures of both bones, one with a fracture of the lower third of the radius) were fixed with Kirschner wires, followed by a plaster cast of the forearm for seven to ten weeks. These healed normally (Figs. 16-A and 16-B).

4. Two cases were complicated. An old Monteggia's fracture, with pseudarthrosis of the ulna and an unreduced dislocation of the radial head, was treated by a medullary pinning of the ulna and resection of the radial head. The end result was good. An old crushing injury of the upper extremity with marked bowing and shortening, and with weakness of the fingers, was treated by osteotomy and pinning of the ulna. This patient had a fair result, with recovery of movements of the hand.

Indications

From our experience with thirteen patients, eight of whom had fractures of both bones, we feel that the method is simpler and gentler than closed reduction. It is technically easier than osteosynthesis with plates, which often results in pseudarthrosis. In the field of simple diaphyseal fractures of the forearm, intramedullary pinning has achieved unquestioned and definite progress, whatever may be the type or location of the fracture. We believe that this method is contra-indicated in compound fractures.

OTHER FRACTURES

We have not used pinning of the clavicle, for we believe that the pin is insufficient to support the weight of the arm. The non-operative method of reduction is superior, since it leaves no scars.

In order to place a pin in the diaphysis of a phalanx or a metacarpal bone, it must be passed through a joint. For this reason we have not used pinning in these locations.

We are putting the finishing touch to a surgical method in the treatment of intertrochanteric fractures, with intramedullary pinning as one of its principles. A report of this will be published later. This cannot be included properly in a discussion of diaphyseal fractures.

SUMMARY AND CONCLUSIONS

1. Osteosynthesis by the medullary route respects the three great principles of treatment of fractures,—reduction, fixation, and mobilization. *Reduction* must be excellent, since the introduction of the pin requires anatomical continuity of the bone canal. In *fixation*, the pin is very strong and firm, and assures a powerful immobilization of the fragments. Since it takes hold through the entire diaphysis, the forces of torsion and flexion are diffused over a wide area. Moreover, the presence of the foreign body in the soft bone accelerates the formation of callus. As to *mobilization*, the use of the limb is recovered rapidly; axial pressure favors osteogenesis and active movements avoid articular stiffness, muscle atrophy, and circulatory disturbances.

2. Experience acquired by us in fifty-five operations has demonstrated the relative simplicity of the method. It is an advance over the other procedures in present use in the treatment of diaphyseal fractures of the most important long bones of the skeleton. These procedures, in order to be successful, require either exceptional skill on the part of the surgeon or great patience and discomfort on the part of the patient. On the other hand, the method is not attended by the serious dangers which we might have anticipated from the theoretical critics.

3. We have described the technique which is recommended for each area, and we have pointed out the difficulties which have been surmounted, as in the application of any new surgical procedure.

4. The results obtained in twenty-three diaphyseal fractures of the femur, ten of the leg, nine of the humerus, and thirteen of the forearm have been analyzed critically. We have outlined the operative indications. We do not advise intramedullary pinning in compound fractures. We recommend it enthusiastically in closed fractures, especially of the femur and of the forearm, where this method gives the solution of a problem not met satisfactorily up to the present time.

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RECONSTRUCTIVE SURGERY IN PATIENTS WITH WAR FRACTURES OF THE ANKLE AND FOOT

BY LIEUTENANT COLONEL SPENCER T. SNEDECOR

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At Valley Forge General Hospital, members of the Orthopaedic Service have had the opportunity for over two years of observing and treating many severe foot injuries in patients who have come back from the various theaters of war. Most of the patients returned from overseas at least four to eight weeks after the occurrence of the fractures, and therefore they were usually in the intermediate phase of treatment. Thus surgery for them was not of an emergency nature. Time and care were taken to study their basic tissue defects and structural defects and to follow the progress of healing. In addition, much thought was given to planning reconstructive surgery, upon the general thesis that a living foot which has reasonable stability, sensation, and comfort, even though it may be seriously deranged, is more desirable than an artificial foot. Only two of the patients required amputation.

When a careful examination of the foot had been completed, a plan of treatment was laid out for the intermediate stage. Final reconstructive surgery might be contemplated, but the foot was often given the test of time and use before this was carried out.

If there was an open wound, the foot was soaked and bathed in sterile, warm, soapy water. The wounds were cleansed; sinuses were probed and irrigated. Loose or exposed pieces of bone and foreign material were removed. The dressing consisted of one layer of close-meshed vaseline gauze to cover the wound surface, with the usual gauze squares on top.

Next the foot was placed, as accurately as possible, in normal weight-bearing alignment under the tibia, with the ankle joint at an angle of 90 degrees. The calcaneus was placed either in a direct line or in slight inversion, but the foot itself was slightly everted. The contour of the foot and of the arches was molded into a relationship as nearly normal as possible, and plaster was applied. The cast was padded as little as possible.

The casts were changed at intervals of one, two, or three weeks, depending upon such factors as the comfort of the patient, the type of injury, and the amount of discharge. The soldiers preferred casts so that they could get up and go about, but occasionally a deep wound behaved better when the foot was elevated in bed and the dressings were changed frequently. Surface wounds healed more rapidly when exposed to the air. Weight-bearing was often begun while the patient was still in plaster, by adding a walking iron. When rigid support could be abandoned, a flexible Unna's gelatine boot or elastoplast was applied.

TRIAL STAGE

The trial stage was a period of weight-bearing in a shoe with proper support. Over a period of weeks and sometimes of months, the patient was watched to see what Nature would accomplish toward banishing the limp and restoring painless weight-bearing. One patient with bilateral fracture of the calcaneus, for example, went back to limited duty for twelve months, before he returned and said that his feet were too painful to continue such activity. Proper walking had to be insisted upon. Arch supports were frequently needed. A metatarsal bar was often helpful in fractures of the tarsus and fore part of the foot, and a Thomas heel added an element of stability and control to the shoe.

The rehabilitation program was built upon three principles:

1. Walking is the best physical therapy for an injured foot.

2. A patient cannot walk on either a swollen foot or on one without adequate shoe support.

FIG. 1-A

FIG. 1-B

Case 1. Private First Class A. R. W. The patient was injured in a jeep collision, in England, in March 1944.

FIG. 1-A: Shows painful unstable ankle joint, with non-union of fibula.

FIG. 1-B: Postoperative result.

3. Swelling can be prevented by adequate elastic support, or it can be relieved by elevation and exercise.

The Physical Therapy Department was of decided aid in promoting the recovery of these feet. The crusty foot with dry skin that had just come out of a cast was benefited by whirlpool baths and oil massage. The foot that was bound up with scar tissue was helped by the softening effect of the baths and manipulation. Proper walking habits were taught. The therapeutic gymnasium had a number of helpful foot exercises, which included use of the bicycle, rowing machine, inclined boards, steps, and mirror walking.

FIG. 2-A

FIG. 2-B

Case 2. Captain B. P. P. (Medical Corps). This officer was injured in September 1943, when he fell from a bicycle during a black-out in England. Open reduction was performed in England after eight weeks, because of non-union.

FIG. 2-A: Screw fixation was unsuccessful.

FIG. 2-B: Union occurred after final operation, with bone graft, in March 1944.

FIG. 3-A

FIG. 3-B

Case 3. Private D. McC.

FIG. 3-A: A Pott's fracture of the left ankle was sustained in January 1945. There was persistent pain on dorsiflexion of the foot, caused by bony proliferation beneath the medial malleolus.

FIG. 3-B: Shows postoperative clearing.

FIG. 4-A

FIG. 4-B

Case 4. Private T. F. Patient was wounded by a mine explosion in March 1943, while riding in a jeep in Tunisia.

FIG. 4-A: Roentgenograms show severe distortion of ankle and subtalar joints and multiple fractures.

FIG. 4-B: Shows postoperative arthrodesis, with sliding bone graft.

GENERAL PRINCIPLES OF SURGERY

The objective of treatment was a painless weight-bearing foot which would carry the soldier through a useful life. To obtain this, the following basic procedures were used, alone or in combination: (1) restoration of structural continuity, where bony defects were present; (2) correction of weight-bearing malalignments; and (3) arthrodesis of joints which were painful or disintegrated.

Flexibility of the foot was secondary to good weight-bearing alignment. A painful joint was much more disabling than a stiff one. Nature was kind to this strong-muscled, youthful group and many men finally recovered fine capable feet. In general, however, a badly damaged foot proved to be handicapped, regardless of how much could be accomplished by skin grafts, bone grafts, joint fusions, or rearrangements of bone alignment.

A number of factors were evaluated in each case before surgery was undertaken:

1. The character of the patient was taken into consideration, in an attempt to find out whether he was making a real effort to use his foot.

2. Accurate localization by examination and roentgenogram were employed to determine the exact cause and source of the pain. The gait was carefully analyzed and the line of the weight thrust down the limb into the foot was evaluated.

3. An estimate of the operative result was made and, if there was a reasonable anticipation of improvement, surgery was advised.

ANKLE JOINT

Complications: Relaxation of the tibiofibular synarthrosis following ankle sprain or fracture was one of a number of late complications of injury around the ankle joint. In Case 1, the whole foot tended to evert and roll outward into a painful valgus position as weight was thrust upon the ankle. Operative interference was helpful in restabilizing the ankle joint. The excess of soft tissue between the two bones, which by now had become a bursa, was curetted out so that the bony surfaces came into lateral contact. Then a bolt was inserted transversely through the fibula and into the inner side of the tibia, about one-half inch above the joint. Nuts and washers were applied to bind these bones tightly together and to restore a rigid joint mortise. After eight weeks, the bolts were removed. In

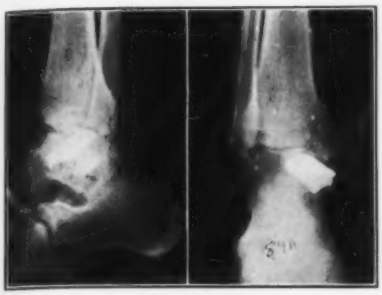

FIG. 5-A

FIG. 5-B FIG. 5-C

Case 5. Sergeant N. R. Patient was wounded by shell fragment, while in Tunisia.

FIG. 5-A: Metal fragment may be seen in joint.

FIG. 5-B: After removal of fragment.

FIG. 5-C: Persistent pain made ankle fusion necessary.

this case, the added complication of non-union of the fibula was the causative factor in loosening the tibiofibular synarthrosis.

Non-Union of the Medial Malleolus: After a Pott's fracture, it was quite common to find that the medial malleolus had not formed firm bony union with the shaft of the tibia. In many of these cases there was strong fibrous union, which served adequately. Pain remained in some cases when the foot was turned inward, however; and these cases were helped by surgery. The corrective operation was not nearly so simple in these late cases as it appeared at first glance. Two or three operative failures were encountered, including one in a medical officer (Figs. 2-A and 2-B). First of all, it was quite difficult to loosen the malleolus sufficiently to bring it into good apposition with the body of the tibia. By the time this had been accomplished, much of the medial ligament had been pried off. The next step was to hold the malleolus in contact. Screws were usually inadequate, because the threads did not hold in the cancellous bone, but occasionally a long wood screw would hold. It was found better to drill a hole across the lower end of the tibia and thread a heavy wire circumferentially through it, under the malleolus. When the wire was tightened, it snubbed the little fragment into place and also left an open surface for a small sliding bone graft. In view of the operative failures, this precaution seemed an additional insurance for union.

Bony Masses or Proliferations Beneath the Malleoli: After ankle fractures, bony masses or proliferations were found either in the anterior part of the medial ligament of the ankle or laterally in the anterior talofibular ligament. Painful dorsiflexion of the foot, with a localized tender mass of bone, confirmed by roentgenogram, was the indication for operative removal. A good result was obtained in Case 3 (Figs. 3-A and 3-B).

Valgus or Eversion of the Foot: This deformity, which occurred frequently after ankle fractures, was caused by outward angulation or displacement either of the lateral malleolus or of both malleoli. It was the most common complication of inadequately reduced ankle fractures of the Pott's type. Experience with the severe deformities (Figs. 4-A and 4-B) has shown the need for extensive reconstruction of the ankle joint. Usually both malloli had to be refractured in order to restore a semblance of the normal joint mortise, and in the severe cases an arthrodesis was done because of the extensive damage to the cartilaginous surfaces of the joint.

Distortions and Irregularities in the Articular Surfaces of the Joint: These abnormalities followed fractures of the tibia or the talus, which involved the joint surfaces. In severe cases, it was evident at once that the gross distortions of the joint surfaces would result in hopelessly painful ankles. In milder cases (Figs. 5-A, 5-B, and 5-C), the damage to the joint surface, particularly that of the talus, was not so severe originally, but as

FIG. 6-A

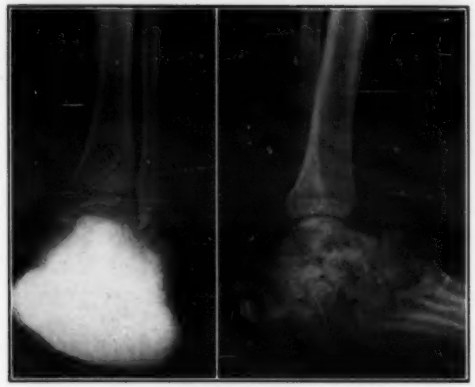

FIG. 6-B

FIG. 6-C

Case 6. Captain C. C. (Medical Corps), a paratrooper. Wounded by machine-gun bullets during initial invasion of Sicily.
FIG. 6-A: Deformed remnant of lateral malleolus is seen above a bulge of the talus.
FIG. 6-B: Much of this mass was removed at first operation, resulting in considerable improvement. Note defect in calcaneocuboid joint.
FIG. 6-C: After a long trial, painful instability forced the patient to request a triple arthrodesis. This was accomplished by bridging the joint defect with a tibial graft and by building up the outside of the talus to equalize the other side.

FIG. 7-A

FIG. 7-B

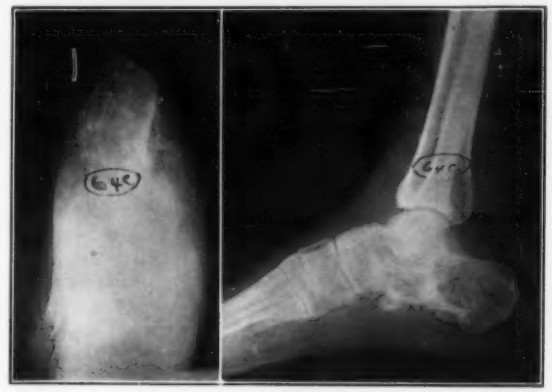

FIG. 7-C

Case 7. Lieutenant J. L. L. Injury occurred when bomb blew up deck of landing craft, on which patient was standing, during invasion of Sicily, in August 1943.
FIG. 7-A: Shows severely comminuted fracture of calcaneus, unreduced after six weeks.
FIG. 7-B: Shows postoperative fixation in a cast, with pin going through into the talus.
FIG. 7-C: Final result.

months went by the joint became more and more painful, and roentgenograms revealed further destruction of the cartilaginous surfaces. The treatment for this type of painful ankle joint was fusion of the joint. A fused ankle joint was found to be not so much of a handicap as might be expected, and the patient in this case walked without a limp.

Some of the operations were performed without a bone graft across the joint, but in most instances early fusion was made more certain by an inlay graft down the front of the tibia into a slot in the talus. The most difficult part of the procedure was to free the ligaments from the malleoli so that the talus was seated firmly against the tibia, after the cartilaginous surfaces had been removed. Care was taken to place the foot in a slightly posterior position and in 10 degrees of equinus. The graft was then cut from the front of the tibia and slid down into the receiving slot in the talus, as shown in Figure 4-B. Three or four months of plaster fixation were necessary, but a walking cast was used for the last two months.

FRACTURES AND DISLOCATIONS OF THE TALUS

These talar injuries gave disabling end results, under the best of conditions. On the Valley Forge Orthopaedic Service, there have been at least a dozen severe talar injuries. The fractures were the result of extreme violence and were often compound and comminuted. The head or body of the bone, or both, were usually dislocated. In three cases the body was dislocated backward and rotated behind the ankle joint, so that it had been impossible to reduce the fracture. Furthermore, the body usually became sclerotic because of inadequate circulation. This group of foot injuries constituted the worst cases. The distortion of the bones often was grotesque. Several of the cases were complicated by simultaneous tibial or calcaneal fractures, or both.

To restore the weight-bearing continuity of the foot without serious pain, two types of reconstructive procedure were performed:

1. *Astragalectomy* (three cases): In the first patient, the body of the talus was dislocated and dead. After excision, the clinical result was only fair. Although his foot was placed properly, so that the tibia was seated just behind the navicular, and circulation was good, the soldier still had a decided limp and some pain. The second patient (Case 8) was an officer, upon whom an astragalectomy had been performed overseas early, because of a bad dislocation and compound fracture. The result was reasonably good. With a built-up heel in a special shoe, he could walk short distances with very little limp or pain. The third patient came back from overseas with a large open wound; the talar fragments were badly

FIG. 8-A

FIG. 8-B

Case 8. Lieutenant L. H. W. Patient was injured in crash of a C-47 plane in Italy.
FIG. 8-A: Roentgenogram shows the dislocation of the talus.
FIG. 8-B: Shows final position, after early astragalectomy overseas.

Case 7. Lieutenant J. L. L. Injury occurred when bomb blew up deck of landing craft, on which patient was standing, during invasion of Sicily, in August 1943.
FIG. 7-A: Shows severely comminuted fracture of calcaneus, unreduced after six weeks.
FIG. 7-B: Shows postoperative fixation in a cast, with pin going through into the talus.
FIG. 7-C: Final result.

FIG. 9-A FIG. 9-B

Case 9. Sergeant F. G. Soldier was injured by shell fragment in Italy, in November 1943.

FIG. 9-A: Roentgenogram shows traumatic arthritis of subtalar joint.

Fig. 9-B: Shows postoperative fusion of subtalar joint.

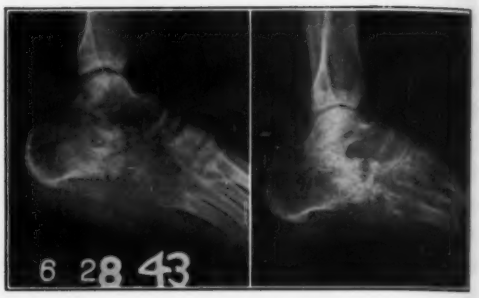

FIG. 10-A FIG. 10-B

Case 10. Corporal S. O. Accidental self-inflicted gunshot wound of foot occurred, through the calcaneocuboid joint.

FIG. 10-A: Before operation.

FIG. 10-B: Shows result after triple arthrodesis.

dislocated. It was necessary to remove all of the pieces before drainage ceased. An eventual fusion between the tibia and calcaneus will probably result.

2. *Arthrodesis of the Ankle or Subtalar Joint for Double Fractures*: In several patients, including Case 4, all three bones had been involved, so that an arthrodesis of the ankle and subtalar joint was necessary. At the time of these operations, a number of questions arose. Should the sclerotic body of the talus be saved? Should tibial bone grafts be inserted to build up defective surfaces in order to equalize the alignment; or should the uneven side of the bone be removed to obtain weight-bearing stability, and thus shorten the foot? Could all of the cartilage be removed to assure fusion; or should a bone graft be slid down from the tibia, along the outer border of the neck of the talus, into the body of the calcaneus? These questions required fine surgical judgment in each individual case, and often they could not be answered until actual conditions were brought to light at the time of operation. The patients in this category had tremendous injuries and a great deal of soft-tissue damage, as well as gross distortion of structure. The foot has been preserved, but the results have been only fair.

A less severe, but complicating, injury with multiple fractures involving the lateral malleolus, the outside of the talus, the calcaneus, and the cuboid is shown in Case 6. The patient was a medical officer with the paratroopers. After the final subtalar reconstruction and fusion, he had a very satisfactory foot.

FRACTURES OF THE CALCANEUS

Many patients with severely comminuted compound fractures of the calcaneus had serious residual problems. This discussion concerns itself with three types: (1) severe unreduced fractures in which the body was so displaced that the tuber angle was grossly changed and, in some cases, was reversed; (2) those in which the fractures, irregularities, or loss of substance entered directly into the subtalar joint and frequently into the calcaneocuboid joint; and (3) those with chronic osteomyelitis of the body of the calcaneus.

1. *Unreduced Fractures*: Several of these fractures required open reduction as soon as the tissue reaction permitted and the wounds were healed. The principles of operation were twofold. First, the general alignment of the bone was restored and the fragments were molded into a contour as normal as possible; and second, a triple arthrodesis of the subtalar, talonavicular, and calcaneocuboid joints was done. Such a problem is illustrated in Case 7. Six weeks elapsed after the original injury before the patient was returned to the Zone of the Interior. The pull of the gastrocnemius had reversed the angle of the body more than 45 degrees, and what was left of the fore part of the calcaneus was severely

comminuted. At operation, the gastrocnemius had to be lengthened one and one-half inches; even then the deformity tended to recur, so that the body of the calcaneus was held down by a pin which passed through it and into the astragalus, as shown in Figure 7-B. The foot was fixed accurately in slight equinus and valgus. The final results in this case and in other cases of this type of fracture have been fairly satisfactory, in comparison with the severity of the fractures.

FIG. 11-A FIG. 11-B

Case 11. Private W. L. P. Patient was wounded by shrapnel in March 1943, in Africa.

FIG. 11-A: Compound comminuted fracture of body of calcaneus resulted.

FIG. 11-B: Wound healed after radical saucerization, unroofing of cavity, and covering with skin flaps.

2. *Deformities of Joints*: The second type of follow-up problem in these calcaneal fractures was the handicapped foot which continued to be painful after a test of weight-bearing. The most common location of this pain was beneath the lateral malleolus, where it was caused by a widening of the calcaneal bulge. In one or two cases where this alone seemed to constitute the disability, a simple operation of gouging out the bulge of bone was followed by definite improvement. In the majority of instances, however, the source of the pain was demonstrated to be in the subtalar, calcaneocuboid, or talonavicular joint, or in a combination of these joints. For simple traumatic arthritis in the subtalar joint, without serious bone deformity, the Gallie operation was done, as in Case 9. This consisted of making a slot in the posterior subtalar joint, through a posterior incision, and inserting a tibial graft. For the more serious deformities, the customary triple arthrodesis was the standard operating procedure and the results were good (Figs. 10-A and 10-B).

3. *Infected Comminuted Fractures of the Body*: This problem was fairly common and was most difficult to conquer. Frequently, compound splintering injuries of the heel became infected, and the persistent low-grade osteomyelitis in the cancellous body of the bone required radical measures before it could be controlled. Case 11 illustrates the problem. After two or three ineffective sequestrectomies, a radical saucerization was performed; the top of the cavity was unroofed; and skin flaps were collapsed into the cavity. Healing then occurred.

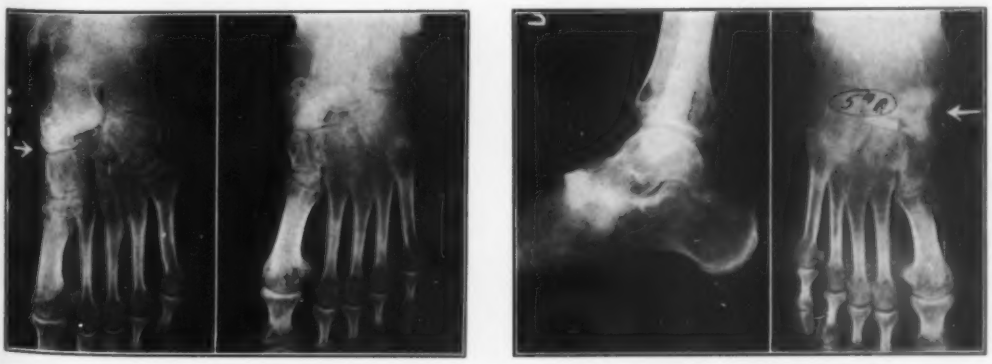

FIG. 12-A FIG. 12-B

Case 12. Private P. R. Gunshot wound of foot by own rifle occurred in Africa, March 1943.

FIG. 12-A: Shows loss of most of navicular.

FIG. 12-B: Shows result after tibial bone grafts fused the space between the talus and cuneiforms.

MID-TARSAL REGION

Here, also, the problems of war surgery were somewhat different from those associated with civilian injuries. Fractures and distortions of the mid-tarsal bones in civilian life result largely from crushing injuries of the foot. In war, they come from gunshot or shrapnel wounds of the foot. At this General Hospital, such injuries were seen often in the intermediate stage, while the wound was still open and there were draining sinuses or deep open pockets into the bone; and later, in the final stage, when the wound had healed with a bad scar which first required replacement with a full-thickness skin graft. When the skin and soft tissues had healed, a period of weight-bearing was allowed to determine the exact structural weakness and the amount of pain which would develop. The circulation and the appearance of the foot improved materially with weight-bearing and exercise, but points of stress began to appear and the rough joints became painful. Roentgenograms helped to disclose the exact structural deficiency or joint irregularity.

Specific problems of the mid-foot were concerned with:

The Navicular: A deformity of the navicular, either into the talar joint or the cuneiform joints, caused disabling pain, because it was in the line of the direct weight-bearing thrust. To eliminate this, fusion across the talonavicular joint was accomplished in several cases by using a small inlay bone graft from the inner lip of the navicular. The results have been fairly good. Case 12 shows a fusion of the talonavicular and cuneiform bones (Figs. 12-A and 12-B). Where marked loss of substance of the navicular had taken place, or there was a distortion of the talonavicular joint, the calcaneocuboid joint had to be evened up in substance and a triple arthrodesis completed. Here, also, reasonably good results were obtained; in the main, the triple arthrodesis gave a good end result in those cases in which it was indicated.

The Cuboid: This bone and its joints were often affected by bullet or shrapnel wounds of the outside of the foot. There was usually so much destruction in the calcaneocuboid joint that a triple arthrodesis had to be done. In two or three instances, an added complication was the loss of bone between the remnants of the calcaneus and the cuboid, so

FIG. 13-A

FIG. 13-B

Case 13. Private W. M. W. Patient sustained gunshot wound of foot by own rifle in foxhole in Africa, in March 1943.

FIG. 13-A: Shows defect in calcaneocuboid articulation.

FIG. 13-B: Shows fusion with bone-graft bridge.

FIG. 14-A

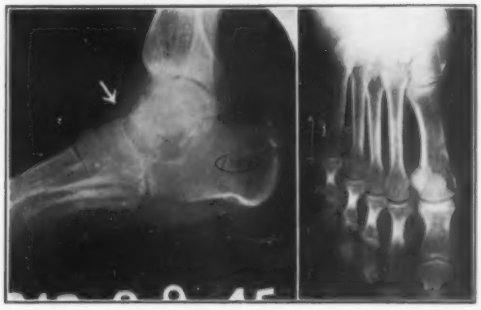

FIG. 14-B

Case 14. J. S. Patient was wounded by shrapnel in Normandy, in July 1944.
FIG. 14-A: Fore part of foot was flail because of loss of most of navicular and cuboid.
FIG. 14-B: Shows the mid-tarsal fusion.

that the foot would have been badly shortened if the navicular had been removed or the talus had been shortened to bring them into contact. The choice in such cases was to bridge the defect with a bone graft (Fig. 13-B). The results here have also been good.

The Navicular and Cuboid: In two cases (Fig. 14-A), both of these bones were blown out in a wound across the foot; and, when the soft tissues had healed, the fore part of the foot was flail. The men walked on their heels, almost as if the fore part of the foot were missing. At operation, the scar tissue was cleaned out, the remainder of the joint cartilage was removed, and the bone remnants were beveled off and matched. The cuneiforms and the remnant of the cuboid in the fore part of the foot were brought into opposition with the talus and calcaneus. Fusion took place and the end result was a much shortened, but reasonably painless and stable foot.

The Cuneiforms: These small bones were quite often affected in mid-tarsal injuries. They sometimes fused spontaneously with each other and with the bones in front of them or behind them. In such instances the result was painless, but a number of patients had persistent bone defects with localized pain. In these instances the cavities were curetted out and filled with bone grafts from the tibia (Figs. 15-A and 15-B).

FIG. 15-A

FIG. 15-B

Case 15. Private J. M. H. Soldier sustained wound of foot by own rifle in Tunisia, in January 1943.
FIG. 15-A: Painful arthritis resulted from destruction of middle cuneiforms.
FIG. 15-B: Shows postoperative fusion of cuneiform area, with bone graft.

Case 16. Private W. W. Q. Wound of foot was received when patient's own rifle discharged, while he was asleep, August 1943, in South Pacific. FIG. 16: Shows defect in first metacarpal, bridged by bone graft.

FIG. 16

FORE PART OF FOOT

The fore part of the foot, with its long trail of disabling injuries, could never be treated lightly in the Army. According to a standard of usefulness to the Army, the results of all real injuries to the metatarsals and toes were disappointing. Therefore, it is evident that Army duty places a heavy strain on the foot.

The Metatarsals: In our experience, multiple metatarsal fractures usually left a painful foot, as far as military duty was concerned. Just what type of surgery to recommend for the painful end results of these fractures was a problem. In one or two instances where there was a definite localized arthritis of a proximal joint, fusion produced a fair result. This procedure could be recommended, provided due care was exercised in the selection of cases, but one had always to determine beforehand whether he could avoid surgery and, by shoe modifications, obtain a reasonable functioning of the foot.

In a number of instances, gross defects in the metatarsals had to be overcome. Loss of substance in the first or second metatarsal was made up by bone grafts, as in Case 16. Gaps in the third and fourth metatarsals were usually left unfilled. The base of the fifth metatarsal, if present, was sufficient for good weight-bearing. Pain-producing deformities of the metatarsal heads were corrected, usually by resecting the offending spurs or bumps carefully but generously. If the whole head had to be resected, the shaft was also taken off well back toward the base. Deep scars were most troublesome in this region.

The Toes: A great many days were spent in Army hospitals because of injuries to the toes. In retrospect, it would seem that far too much time and effort had been devoted to the rehabilitation of little toes. They should have been amputated early, if this procedure was indicated. The big toe presented a serious problem when chronic infection set in, which kept the bone draining for months and also involved the joints.

To clear up this chronic osteomyelitis, it was found necessary to watch closely and to curette out sequestra as early as possible. As soon as the infective process cleared, the residual problem was evaluated. Sometimes the principal handicap was a sensitive scar, and the end of the toe could be partially amputated in order to get enough good skin to cover the scarred area. If the proximal joint became ankylosed or painful, the operation of choice was the Keller procedure, in which the base of the first phalanx was resected. If the interphalangeal joint was involved, the joint surfaces were curetted, so that they would fuse.

SUMMARY

A large number of patients with severe, complicated fractures of the ankle and foot returned from overseas to Valley Forge General Hospital. The reconstructive bone surgery on these cases was interesting and instructive, but often it was only one phase of rehabilitation. Surgery itself could meet the following structural demands: restoration of bone defects by grafts, correction of malalignments by osteotomies, and elimination of painful joints by fusion. The final results were difficult to classify and compare, except on an individual basis. The general impression was that they were satisfactory, considering the severity of the injuries.

THE USE OF PEDICLED MUSCLE FLAPS IN THE SURGICAL TREATMENT OF CHRONIC OSTEOMYELITIS RESULTING FROM COMPOUND FRACTURES

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Perkins states that infection of the bone is an almost inevitable sequel to a penetrating wound associated with a fracture. The inflammation is unlike that caused by blood-borne organisms in that local symptoms and general toxaemia are both less, probably because, from the very beginning, there is free drainage from the broken bone.

This osteomyelitis usually pursues one of two courses. Either (1) it clears up within a short time with adequate treatment; or (2) it resolves itself into chronic osteomyelitis, with a draining sinus leading through the soft tissues to the skin. A few cases may persist as acute osteomyelitis. In some patients the infection may heal, but have recurrent acute episodes. Some of the patients with chronic osteomyelitis may also have acute attacks.

It is with the cases which resolve themselves into chronic osteomyelitis, with a persistent draining sinus, that this paper is concerned. Such cases present problems which are dealt with at an Orthopaedic Unit.

A draining sinus usually indicates: (1) the presence of a foreign body or a sequestrum; or (2) the continuation of a chronic infection of bone. The roentgenogram is helpful in determining the presence of a sequestrum or a foreign body; but occasionally the foreign body is not radiopaque, and small sequestra may sometimes be difficult to detect by roentgenogram. Chronic infection of bone is often associated with the presence of sequestra and of abscess in the affected bone, either alone or in combination. All of the cases reported were of chronic infection of the bone, and the surgical treatment included removal, or attempted removal, of the involved part. No case of simple removal of a sequestrum or foreign body is included.

A series of cases in which pedicled muscle flaps were deliberately rotated into osteomyelitic cavities, following surgical attack on the involved bone, were studied and compared with a series of cases given similar surgical treatment, without the use of muscle transplants. In all of the cases reported, the wounds were closed at the time of surgery.

The following attempts at filling the bone cavity left by a surgical attack on chronic osteomyelitis have been reported:

1. Transplants of free fat have been used by Dunn, Forrester, and Leonte.
2. Plastic methods of closing osteomyelitic cavities by the use of skin and soft tissue have been described by Lord.
3. Sterilized and pulverized resected bone was used by Henschen, following subperiosteal resection.
4. The use of muscle flaps and muscle transplants has been discussed by Avelino and Alberto Gutierrez, by Marques, and by Stotz.

Dickson and his associates and Key reported favorable results in the surgical treatment of chronic osteomyelitis by the use of sulfonamides, generally and topically, and primary wound closure. The results with the technique described here have not been so good as theirs, in spite of the added advantage of a generous supply of penicillin.

SURGICAL TREATMENT

Group A: Use of Pedicled Muscle Flaps

There were thirty-two patients in this group. All had chronic osteomyelitis as a result of a penetrating wound and a compound fracture which had a draining sinus to the skin. The usual history was that, since the patient had been wounded, there had been a con-

tinuous discharge of purulent matter from the involved part. The time interval between injury and the operative procedure varied from four to ten months; in two cases it was twenty-seven and twenty-eight years. In a few cases the wound had been closed for short periods of time in the past.

Preoperative Preparation

Blood transfusions were used in many cases in which the plasma-protein level and hemoglobin had become lowered as a result of prolonged infection of bone.

Sodium penicillin was injected intramuscularly. The dosages varied from 15,000 to 25,000 Oxford units, every three hours. The injections were started forty-eight hours before operation and were continued for periods varying from five to fourteen days after operation. The author favors giving 25,000 units for from seven to eight days, by either intermittent injection or continuous intramuscular drip.

Some information was gained by the preoperative injection of the draining sinus with iodized poppy-seed oil, and by roentgenograms. It was also thought that methylene blue, injected twenty-four hours before operation, was of some value during the actual operative procedure. It was not used, of course, when radiopaque oil had been utilized.

Operative Procedure

1. Careful excision of the sinus tract and of the involved soft tissue is important.

2. Fairly radical attacks on the involved bone are deemed necessary. A moderately large amount of bone was removed in every case in an effort to eradicate the focus, to drain any abscesses that might be present, and to remove all sequestra. This sometimes necessitated the removal of a small amount of normal bone.

3. The whole wound is then washed with large amounts of normal saline solution or dilute penicillin solution, in a strength of 1 to 250. Penicillin cream and a 50 per cent. mixture of sulfanilamide-sulfathiazole powder are swabbed generously into the entire wound.

4. A muscle transplant, with a pedicle attached to the main muscle, is then prepared from a muscle which is most convenient to the osteomyelitic cavity. This is a relatively simple procedure, although a knowledge of the innervation and the blood supply of the muscle being used is essential. Since most of the muscles associated with the long bones pursue a longitudinal course, the transplant may be prepared from a proximal or a distal direction. It is best to have the pedicle as close to the involved bone as possible. The muscle flap is prepared to approximate the size of the bone defect, and it is then directed into the cavity. Severe twisting or angulation of the muscle is to be avoided. It is not necessary to anchor the muscle to the bone with sutures.

5. The soft tissues are then closed, if possible, and the skin is approximated with interrupted silkworm sutures, without drainage.

6. A plaster-of-Paris cast is then applied.

Postoperative Care

Penicillin is continued for periods varying from five to fourteen days, as mentioned previously. The plaster cast is usually removed in two weeks and the wound is inspected.

TABLE I

Bone Affected	Number of Cases	Number Which Remained Closed After Surgery
Femur	10	9
Tibia	12	9
Humerus	8	7
Ilium	2	2
Totals	32	27

FIG. 1-C FIG. 1-D

FIG. 1-A FIG. 1-B

Case 2. Right humerus, before operation.
Fig. 1-A: Anteroposterior view.
Fig. 1-B: Lateral view.

After operation.
Fig. 1-C: Anteroposterior view.
Fig. 1-D: Lateral view.

Results

Of the thirty-two wounds which were handled in this manner, twenty-seven, or 84 per cent., have remained closed (Table I).

Bacteriology

In many of the cases there had been contamination with penicillin-resistant organisms such as *Bacillus proteus, Bacillus pyocyaneus,* coliform organisms, including *Bacillus coli,* and some hemolytic streptococci (which were proved to be resistant to penicillin by special testing). These bacteria were present in wound cultures, in addition to the organisms which are considered to be susceptible to penicillin. Of the twenty-seven patients whose wounds remained closed after surgery, the preoperative cultures on twenty-three (85 per cent.) revealed the presence of one or more organisms of the penicillin-resistant group. In the five patients whose wounds did not remain closed after surgery, penicillin-resistant organisms were found in three cases, or 60 per cent.

Group B

This group of forty cases was reviewed for comparison with Group A. Both groups were handled and treated surgically in an identical manner, except that no deliberate muscle flap or transplant was rotated into the osteomyelitic cavity. In eight cases in Group B, a rubber tube was left in the wound for penicillin irrigations. The author's experience with this method of treatment has not been favorable.

Results

The results are shown in Table II.

TABLE II

Bone Affected	Number of Cases	Number Which Remained Closed After Surgery
Femur	16	6
Tibia	14	6
Humerus	6	4
Radius	2	1
Pelvis	2	0
Totals	40	17

The wounds remained closed after surgery in 43 per cent. of the patients.

Bacteriology

Of the eighteen patients in this group whose wounds remained closed following surgery, penicillin-resistant organisms were cultured in five instances, or 28 per cent. In the twenty-two cases which did not remain closed, penicillin-resistant organisms were found in fifteen cases, or 68 per cent.

A few favorable cases are reported. All are from Group A and were treated by the method described; muscle flaps were used in the cavities of the long bones.

CASE REPORTS

CASE 1. R. W., a white male soldier, aged twenty-five, sustained a compound fracture of the left humerus on July 23, 1943, from machine-gun fire. On physical examination he had union of the fractured humerus, clinically and roentgenographically, but he had a draining sinus on the posterolateral aspect of the arm at the junction of the upper and middle thirds, in the region of a partially healed scar. Several sequestra were seen by roentgenogram. A culture contained *Bacillus proteus* and *Staphylococcus aureus.* An operation on the sinus tract, scar tissue, and bone was performed in December 1944. A muscle flap from the triceps muscle was rotated into the bone cavity. The wound healed in ten days. Six and one-half months later there was no recurrence of the disease.

CASE 2. A. B., a white male, aged fifty-five, was injured in 1916 by shrapnel. He had a compound fracture of the right humerus with resultant chronic osteomyelitis. The wound had been draining intermittently since the injury, and had never been closed for more than three months. Physical examination revealed a draining sinus on the medial aspect of the lower humerus, which was the center of a three-inch scar (Figs. 1-A and 1-B). *Staphylococcus aureus* and *Bacillus coli* were cultured. At operation in May 1945, a muscle flap, which was attached to the triceps muscle, was used in the osteomyelitic cavity. The wound had healed when the plaster was removed, in eighteen days (Figs. 1-C and 1-D). Three months later, the wound was still closed.

CASE 3. H. F., a white male soldier, aged thirty-four, was injured in May 1944 by shrapnel, and sustained a compound fracture of the upper humerus and scapula. The wound had never been closed. Physical examination disclosed a draining sinus on the anterolateral aspect of the upper third of the left humerus, in the center of a four-inch scar (Fig. 2-A). *Staphylococcus aureus* was obtained on culture. At operation, in October 1944, a flap of deltoid muscle was used in the bone cavity. The wound had healed in ten days, and there was no recurrence in eight months (Fig. 2-B).

CASE 4. G. A., aged thirty-two, a white male soldier, was injured in May 1944, and sustained a compound fracture of the right tibia with resultant chronic osteomyelitis. Physical examination revealed a draining wound on the anteromedial aspect of the middle third of the right tibia (Fig. 3-A). A culture contained *Staphylococcus aureus* and *Bacillus coli*. Operation was performed in February 1945, and a muscle flap from the soleus was used in the bone cavity created (Fig. 3-B).

CASE 5. A. H., a white male soldier, aged twenty-five, sustained a compound fracture of the left tibia in June 1944, due to shrapnel. Physical examination disclosed a draining sinus on the anteromedial aspect of the left tibia. Hemolytic streptococci and diphtheroids were present on culture. Operation was performed in March 1945; a muscle flap from the soleus was used in the osteomyelitic cavity. The wound healed in three weeks and there had been no recurrence in four months.

CASE 6. E. M., a white male soldier, aged twenty-three, sustained a compound fracture of the right tibia in August 1944, from a shrapnel wound. This wound had never been completely closed since the injury occurred. Examination revealed a draining sinus and a wound on the anterolateral aspect of the upper third of the right leg (Figs. 4-A and 4-B). A culture was positive for hemolytic *Staphylococcus*

FIG. 2-A
Case 3. Left humerus. Before operation.

FIG. 2-B
After operation.

FIG. 3-A
Case 4. Right tibia. Before operation.

FIG. 3-B
After operation.

FIG. 4-A

FIG. 4-B FIG. 4-C

Case 6. Right tibia.
Fig. 4-A: Anteroposterior view before operation. Fig. 4-B: Lateral view before operation.
Fig. 4-C: Lateral and anteroposterior views after operation.

albus and *Bacillus proteus*. At operation, in April 1945, a muscle flap from the tibialis anterior was used in the cavity (Fig. 4-C). The wound healed in sixteen days, with no recurrence of drainage.

CASE 7. L. D., a white male soldier, aged twenty-eight, received a shrapnel wound of the left femur in September 1944, and sustained a compound fracture. Examination revealed that the fracture had healed clinically. (This was confirmed by roentgenogram.) There was a wound and a draining sinus on the medial aspect of the lower third of the thigh. It had drained constantly since he had been wounded. *Bacillus proteus* and diphtheroids were present on culture. Operation was performed in April 1945, and a muscle flap from the vastus medialis was used in the osteomyelitic cavity. The wound healed in three weeks, with no recurrence in four months.

CASE 8. C. L., a white male, aged fifty-five, sustained a compound fracture of the right femur in 1918, with osteomyelitis. He had had intermittent drainage from a sinus on the lateral aspect of the thigh since that time. Examination revealed a draining sinus on the lateral aspect of the middle third of the right thigh. A culture was positive for *Staphylococcus aureus* and *Bacillus pyocyaneus*. At operation, in December 1944, a muscle flap from the vastus lateralis was used. Plaster was removed in twenty days, and at that time the wound had healed. There had been no recurrence in six months.

CASE 9. H. H., a soldier, aged twenty-five, sustained a shrapnel wound in January 1944, which resulted in compound fracture of the right femur with resultant chronic osteomyelitis. Examination revealed a draining sinus on the posterolateral aspect of the region of the greater trochanter. *Staphylococcus aureus* and *Bacillus pyocyaneus* were obtained on culture. Operation was performed in January 1945, and a muscle flap from the gluteus maximus was rotated into the cavity. The wound healed in fourteen days, with no recurrence in six months.

CASE 10. G. H., a white male soldier, aged twenty-nine, was injured in December 1943 by machine-gun fire, and sustained a compound fracture of the left ilium. Examination revealed a draining sinus and an old wound on the lateral aspect of the right iliac crest. Staphylococci, both hemolytic and non-hemolytic, were obtained on culture. Operation was performed in January 1945, and a portion of the gluteus medius was placed in the cavity produced. The wound healed in twelve days; no recurrence had taken place in six months.

USE OF MUSCLE TRANSPLANTS

Femur: The femur is covered by muscle in all of its middle third, most of its lower third, and part of its upper third. If the focus of infection is in the middle or lower third, either the vastus medialis, the vastus lateralis, or the vastus intermedius may be used. It is easier to design a pedicled muscle flap from the vastus lateralis or the vastus medialis than from the more closely adherent intermedius, which is usually involved in the infectious process. In the upper third of the femur, portions of the vastus lateralis, the gluteus maximus, and the tensor fasciae latae are available for transfer, depending upon the location of the focus.

Tibia: Difficulty arises here, since the easiest exposure to the bone is through an anteromedial incision, and in many cases the osteomyelitis involves the anterior cortex of the tibia. This obstacle can be overcome by removing additional bone from either the medial or the lateral border of the tibia, as the case dictates. In this manner a muscle flap can be placed in the cavity. Thus in the upper three quarters of the tibia, a portion of the tibialis anterior can be used from the anterolateral site; from the posteromedial site, the medial head of the soleus is available. In the lower quarter of the tibia, it is somewhat difficult to use a pedicled muscle flap because of the lack of available muscle.

Humerus: In the upper half of the humerus, the deltoid muscle is used. The triceps has been used in practically all positions in this bone.

General Considerations

It must be emphasized that a knowledge of the nerve and blood supply of the muscle to be used is necessary, and that the muscle flap should have a connection with the main muscle through the pedicle. Transfers of free muscle are not recommended. No serious disturbance of function has resulted from the use of a portion of the main muscle for this purpose.

The procedure is flexible. At times the muscle of choice is involved in the chronic inflammatory process and a transplant from another muscle in the vicinity can be used.

DISCUSSION

The author agrees with Key's statement that: "In chronic osteomyelitis, continuous administration of the drug over a long period will lessen the amount of discharge, but it will not cure the disease, because it cannot sterilize dead bone or cavities with necrotic contents and rigid walls". The problem is a mechanical one and it is felt that, besides the necessity of removing dead and infected bone and soft tissue, it is equally important to deliberately fashion a muscle flap and place it in the bony defect created, if elimination of the focus of infection and of the draining sinus is anticipated.

In some positions the use of a pedicled muscle transplant in an osteomyelitic cavity is impossible, either because the muscle has been involved in the disease process, or because it is normally too distant from the part. However, the method has a wide application.

The favorable results following the use of muscle in bone after adequate surgery cannot be attributed alone to the use of penicillin, administered systemically or used topically. Penicillin will diminish the possibility of spread of infection by penicillin-sensitive organisms and would seem to have favorable effects on the same organisms when used locally, if it is directly in contact with these bacteria.

CONCLUSIONS

1. The use of pedicled muscle flaps in the surgical treatment of chronic osteomyelitis is a useful procedure, since 84 per cent. of the wounds remained closed after operation. In cases treated identically, except that a muscle transplant was not rotated into the osteomyelitic cavity, only 43 per cent. of the wounds remained closed after operation.

2. The use of pedicled muscle flaps is recommended in the surgical treatment of chronic osteomyelitis from any cause, and its application is certainly not limited to chronic bone infection following gunshot wounds and compound fractures.

3. Muscle which has been deliberately placed in osteomyelitic cavities at the time of surgery would appear to have a favorable effect on penicillin-resistant organisms. In twenty-three out of twenty-seven cases which were contaminated with such bacteria, or 85 per cent., the wounds remained closed.

4. No significant disturbance in muscle function was observed after the use of a portion of the main muscle to obliterate the bone cavity which had been created surgically, and no serious untoward reactions occurred locally or generally from the closure of these wounds.

NOTE: The author is indebted to Dr. Jack Naden, consultant to the Orthopaedic Unit, for his advice and encouragement in the use of the procedure which has been described; and to Wing-Commander R. Robertson, for permission to publish this article.

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CONDYLAR MOVEMENT IN THE STUDY OF INTERNAL DERANGEMENT OF THE TEMPOROMANDIBULAR JOINT

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The normal advance of each mandibular condyle beneath the articular eminence or anterior to it is synchronous and equal when the mouth is opened, as is its retreat into its socket when the mouth is closed. Because the condylar advance is equal and even, the chin does not shift to either side. The joint moves soundlessly. The two condyles act as a unit, since the mandible is shaped like a horseshoe.

The condyle normally leaves its socket when the mouth is opened between one-quarter of an inch and three-quarters of an inch, but it remains within the limits of the capsule of the joint. This may be called a dislocation, if comparison is made with the behavior of other joints (Figs. 1, 4-A, and 4-B). Hence, it may be said to be the only joint which dislocates normally. The average mouth opening does not exceed one and three-quarters inches, and two inches or more is unusual. The angle of the jaw, by indirect or lever action, controls mouth opening. The angle must be obtuse for good opening; the average angle is between 120 and 130 degrees. The angle of the jaw is significant mechanically in the forward thrust of the condyle in opening the mouth. A lesser angle means less thrust in mouth opening, and a greater angle forces the condyle more easily under the eminence (Table I).

TABLE I

CORRELATION BETWEEN ANGLE OF THE JAW AND MOUTH OPENING IN THE NORMAL INDIVIDUAL

Sex	Age (*Years*)	Angle of Jaw (*Degrees*)	Mouth Opening
Male	20	108	1¾ inches
Male		130	1¾ inches
Male	26	128	
Male		110	1⅝ inches
Female		116	
Male		130	
Female		120	⅞ inch
Male	61	120	1¾ inches
Female	9	132	Good
Male	21	125	1¾ inches

Asynchronous condylar movement produces unequal condylar advance. The more rapidly advancing condyle causes a shift of the chin to the opposite side, which is corrected only when the slower condyle reaches an anterior position equivalent in distance to that of its faster mate. If the slower condyle cannot move as far anteriorly, the shift persists. The retreat of each condyle is different, as the mouth is closed. The less forward condyle retreats into its socket first, since it goes a shorter distance. Deviation of the chin persists or is increased until the other, more anteriorly placed, condyle enters its socket. The shift of the chin is always *away* from the side of greater condylar motion, and does not indicate *per se* the side which is involved.

Normal lateral motion of the jaw is equal in range and involves the advance (anterior motion) of one condyle with the synchronous retreat (posterior motion) of the other. It is important to remember this in considering the inequality of lateral movement by meniscal derangement (Fig. 1). If the advance of one condyle has been stopped by meniscal block, the synchrony of lateral movement is disturbed. Lateral motion is greater *toward* the side of involvement, since the normal condyle can advance and retreat, while the affected condyle cannot move forward (Figs. 2-A and 2-B). If the retreat of the condyle has been blocked, the greater lateral movement is *away* from the side of involvement (Figs. 3-B and

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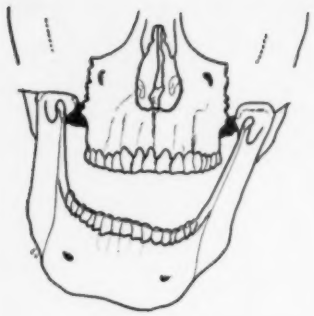


FIG. 1

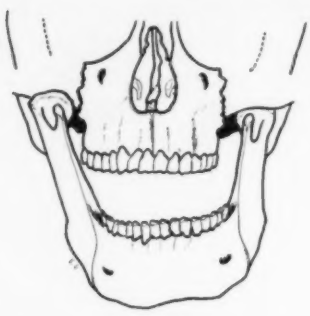


FIG. 2-A

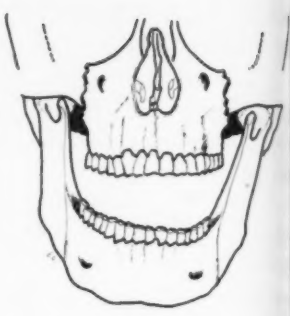


FIG. 2-B

Fig. 1: Normal right lateral movement is shown. The left condyle moves forward and the right moves backward. In left lateral movement, the reverse takes place.

Fig. 2-A: It is assumed here that the left condyle is fixed in its socket. On mouth opening, the right condyle moves anteriorly, given its full range of motion, and the jaw shifts to the left.

Fig. 2-B: Left lateral motion is greater than right, since the left condyle, being more or less fixed, cannot advance. In fixation of the left condyle, the jaw shifts to the left on mouth opening and left lateral motion is greater than right.

FIG. 3-A

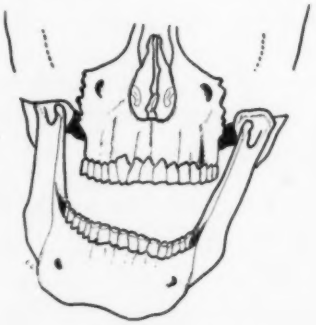


FIG. 3-B

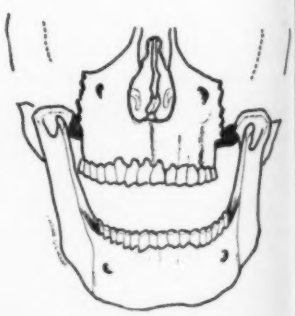


FIG. 3-C

Fig. 3-A: This situation is the reverse of Fig. 2-B. The left condyle is placed anteriorly and cannot be reduced because of meniscal block. The chin goes to the right on mouth opening, because the left condyle is ahead of the right.

Fig. 3-B: Right lateral movement is greater than left, because the left condyle is ahead of the right.

Fig. 3-C: Left lateral motion is less than right, because the left condyle cannot retreat into its socket.

3-C), and on mouth opening the chin shifts to the opposite side (Fig. 3-A). Lateral motion is tested with the mouth partly open.

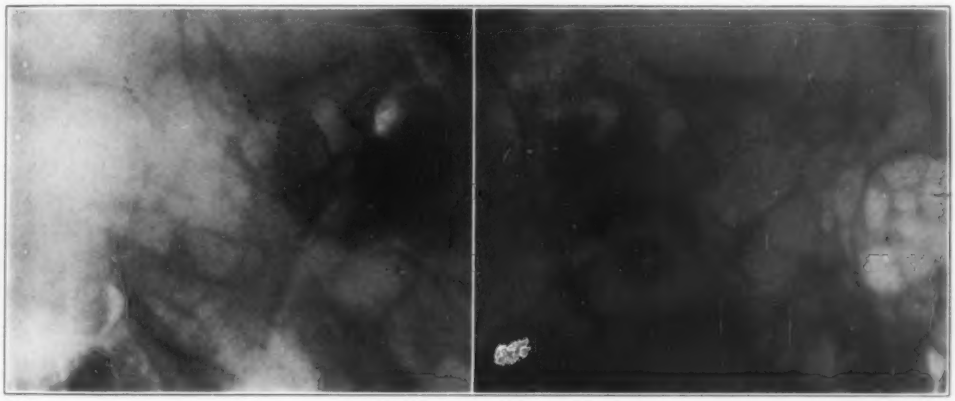
It is then possible, by analysis of jaw movement, to know which joint is involved and whether it is in or out of its socket. Thus, if the right temporomandibular joint is fixed, the chin shifts to the right in mouth opening and right lateral motion is greater than left. If the right condyle is out of its socket, the chin swings in mouth opening either to the right, if it is fixed in this position, or to the left, if it shows more anterior motion than the left condyle. Right lateral motion is less than left, however, since the right condyle cannot retreat. If the affected joint is very painful, or if the meniscus is not yet "set" or fixed so that lateral motion of the jaw is not carried through a range of movement definite enough for diagnosis, it may not be possible to use these criteria. Diagnosis is then based on the repeated observations of the patient.

There are many reasons why one condyle may move more quickly than its mate, but it is usually an interposed meniscus that stops condylar advance or retreat. Incongruence of the joint surfaces follows joint inflammation more frequently than it does meniscal interposition. Anatomical abnormalities, such as a shallow fossa or a small anterior tubercle, are secondary factors. The condyle may not be able to leave its socket, first, because of meniscal block, and second, because of shortening and thickening of the capsule

and ligaments. Conversely, the condyle may not be able to return to its socket, either because the capsule has become loose or because it has become shortened and thickened.

The derangement of one joint affects its mate, either by obliquity of movement of the jaw when the normal joint moves through its full range, or by partial fixation of the normal condyle. The latter condition occurs more frequently in the acute phase of the illness, particularly as the result of pain; the former occurs in the chronic phase. After operation, both condyles should and do move more evenly and synchronously near or beneath the articular eminence, without a shift of the chin to one side or the other, unless condylar movement in the operated joint is restrained by bone block, or by residual ligamentous and meniscal block. The fixed joint—and the injured joint may become fixed in a few hours or a few days—may show some motion, which is usually insufficient to bring its condyle forward. Fixation may be greater roentgenographically than clinically.

The trauma which causes loosening or tear of the meniscus may be either intrinsic or extrinsic; extrinsic trauma is either direct or axial. Men are more frequently injured by extrinsic trauma, women by intrinsic trauma. The intrinsic injuries, such as yawning, chewing, talking, the dropping of the jaw in sleep, dental malocclusion, and prolonged mouth opening, as in dental work, do not impress themselves on the mind of the patient as do the grosser, blunter, extrinsic traumata. The onset of disability in intrinsic trauma is



Left Right

FIG. 4-A

Roentgenograms of the normal temporomandibular joint, taken with the mouth open one-quarter inch (left joint) and three-quarters of an inch (right joint). The condyle goes under the eminence between one-quarter and three-quarters of an inch of opening.

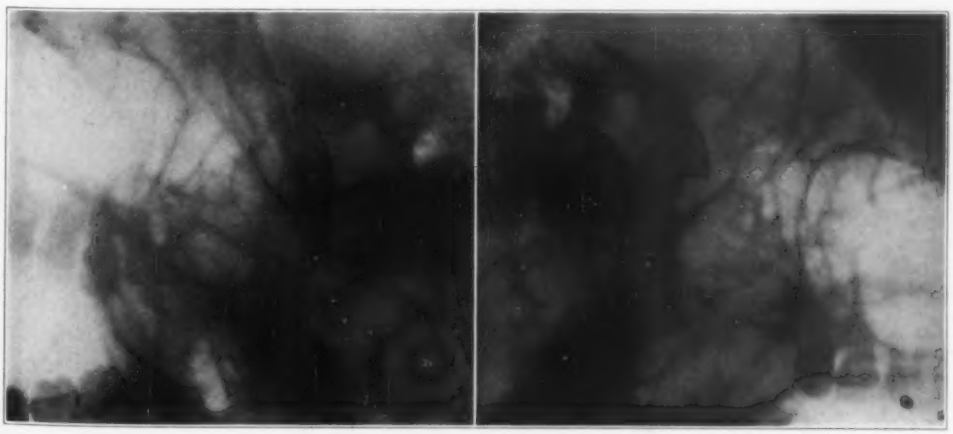


FIG. 4-B

The left joint is shown at one and one-quarter inches and the right joint at one and three-quarters inches of mouth opening. Each condyle is anterior to the eminence.

gradual or sudden, and one characteristic observation is the aggravation or onset of acute disability in the morning, after the jaw has been relaxed during sleep.

A blow to the jaw, at or near the temporomandibular joint, or an axial blow to the chin whose force is sent to the opposite condyle, causes sudden contraction of the pterygoideus externus; the pull of this muscle forces the meniscus forward and medially. The intrinsic traumata keep the condyle in a forward position. The temporomandibular joint becomes painful and the adjacent area may be swollen. An annoying click may be heard or felt as the mouth is opened or closed. In the acute stage, the patient cannot open his mouth freely or painlessly, and finds it hard to chew solid food. Condylar motion is usually restricted and the chin shifts to the abnormal side, because the normal joint moves faster than the abnormal joint. If the condyle has been dislodged from its socket, the chin may go to the normal side, since it is placed ahead of its mate. In the latter event the mouth can be closed, but deviation of the chin persists.

As the acute stage subsides, all symptoms and signs lessen. Clicking is not necessarily present. The ability to open the mouth fully may return and the temporomandibular joints may become functionally useful, but permanent inequality and asynchrony of motion may remain. Apparently, enough of the meniscal cartilage is eroded to allow useful function, or it may be placed in such a position medially that it is by-passed by the condyle.

No clinical attempt has been made to dissociate the two movements of the joint,—the *hinge* movement, which takes place in the joint formed by the condyle and the meniscus, and the *gliding* movement in the joint, between the meniscus and the fossa. As a result of acute injury, both actions may be disturbed and the two-jointed temporomandibular joint may behave as a single joint. It is important to determine the integrity of the joint as a whole.

Most patients are treated by rest, heat, and the chewing of soft food. The clicking joint is sometimes treated by the injection of sylnasol, an irritating solution of the sodium salts of certain of the fatty acids of psyllium-seed oil. In the presence of a persistently painful joint, with or without locking, limited mouth opening, and the inability to chew solid food, operation is indicated. The irreducible, anteriorly placed condyle should be replaced.

This study is based upon the clinical examination of the temporomandibular joints of 105 patients; fifty-five were normal and fifty were abnormal. Roentgenographic examinations were made in many cases.

Meniscal disability has been separated categorically into several groups. These need not be distinct, for one group may merge with the other.

THE CLICKING JOINT

The clicking joint is the simplest form of internal derangement. The meniscus is loose or torn, but it does not block condylar motion. Its interposition, however, causes transient or permanent asynchrony of condylar movement. The derangement, especially when it has been produced by intrinsic trauma, occurs preponderantly in women, especially young women. It usually causes slight or no trouble, but in some patients more serious symptoms eventually develop, and these patients may need meniscectomy. The joint may lock temporarily, with the mouth open or closed.

The discontinuance of clicking means one of several things: reposition of the condyle; wearing away of the meniscus; fixation in an abnormal position, as after manipulation; injection of an irritating substance; or operative resection of the meniscus. Manipulation of the jaw intentionally, as under anaesthesia, or unintentionally, as in dental work requiring prolonged mouth opening, may improve the joint whose motions are restricted or it may cause further restriction. It should always be done gently.

Three main forms of clicking joint are described,—the usual anterior form, the unusual lateral form, and the painful anterior form with transient locking.

The Usual Anterior-Motion Form of Clicking Joint

CASE 1: A woman of thirty-five, who was first examined on February 23, 1940, had heard clicking of her left temporomandibular joint for the past year. The click was not constant; it was worse in rainy weather; and it was not caused by trauma or by chewing hard foods. Both condyles had good anterior excursion, especially the left condyle, and the lateral movement of the jaws was good. The patient opened her mouth one and one-quarter inches, with slight shift of the chin to the right. Roentgenograms, taken on February 29, confirmed the anterior excursion of the condyles, but it was not possible to tell which was more anterior. Injections of sylnasol were advised, but the patient refused to have them.

On March 6, 1943, she had no pain in the left temporomandibular joint, but there was occasional clicking. She opened her mouth one and three-eighths inches, but the chin deviated to the right because of greater movement of the left anterior condyle. The left condyle was more prominent. In mouth closing, the right condyle entered its socket first, and, when the left condyle retreated into its socket, the deviation of the chin was corrected. The more quickly advancing left condyle was placed in a position ahead of the right one, and the right condyle could therefore enter its socket first.

This case is illustrative of mild permanent asynchrony of condylar movement in the clicking jaw caused by meniscal interposition.

Clicking Joint Relieved by Injection of an Irritating Solution

CASE 2: A male patient was seen on March 3, 1944. He had had constant, annoying snapping or thudding of his right temporomandibular joint for a year, without known injury. Each day the joint snapped hundreds of times, and sometimes the patient himself would cause it to snap by shifting his jaw to the left. The joint felt worse each morning on arising, although it did not snap more. He had discomfort of the ear. The joint occasionally locked and for a week, six months before examination, he was afraid to open and close his mouth, especially in the morning, for fear of causing the joint to lock. He had formerly slept with his head on his right arm, but abandoned this way of sleeping because it pushed his jaw to the left and, he believed, aggravated the tendency to transient locking.

He opened his mouth one and five-eighths inches. The chin sometimes shifted to the right on partial opening of the mouth, and then to the left on full mouth opening. A thud was heard in the right joint as he opened his mouth from one-half inch to three-quarters of an inch. With his mouth closed, the thud was heard as he shifted his jaw to the left, but not to the right. Lateral motion was somewhat greater to the right than to the left. The joint was not tender.

On March 14, one cubic centimeter of two per cent. procaine was injected into the joint, just behind the condyle, with the mouth open. This had no effect. On March 15, 0.2 cubic centimeter of sylnasol was injected, by similar technique, into the joint. There was no local reaction. On March 20, the patient stated that the snapping had diminished greatly. He felt much better, enjoyed his meals, and was not troubled by the jaw. Objectively, slight clicking occurred with every third or fourth opening of the mouth, and the joint moved more smoothly. He still could snap the joint voluntarily. On April 26, the jaw did not snap and he could open his mouth one and three-quarters inches. He had no complaints.

The Lateral-Motion Form of Clicking Joint

CASE 3: A man, forty-nine years old, whose jaws were examined on July 2, 1940, was being treated for aseptic necrosis of the hips resulting from caisson disease. The jaw findings were incidental but interesting, illustrating condylar asynchrony by lateral movement rather than by anterior movement. The patient had occasional pain in the joint of each jaw on chewing hard food. He had noted catching of the right temporomandibular joint as he opened his mouth suddenly and swung it to the right. This happened about once a month, and he reduced the dislocation easily by pushing his jaw to the left. The catching had been observed for four or five years and was correlated with no known trauma. Sometimes he had a peculiar feeling in the right ear.

On opening the mouth, both condyles moved anteriorly with a thud, and they retreated with a thud on mouth closing. The chin did not shift on anterior movement. The patient could move his jaws laterally with unusual facility. On right lateral motion, with the mouth partly open, the left condyle became prominent anteriorly and medially and the right condyle was placed posteriorly and laterally. The reverse took place on left lateral movement. Each condyle, especially the right, entered its socket with a thud.

Roentgenograms of the laterally shifted jaw, taken on July 15, showed the anterior position of the condyle on the side away from the direction of movement. The condyle was distorted and broadened.

This is an unusual form of disability, since the important condylar motion is anterior and not lateral. It is a dissociated form, in which anterior movement is free and lateral motion gives the symptomatic clicking as the condyle passes the interposed meniscus.

The Painful Clicking Joint with Transient Locking

CASE 4: A woman, thirty-four years old, was examined on September 14, 1943, and stated that she had had pain in the left temporomandibular joint for two months. This apparently followed prolonged mouth opening during a dental treatment, three months before. No other trauma was known. Intermittent pain began two days after the third dental treatment. Lockings developed two weeks before examination.

The jaw caught every few minutes as the patient opened her mouth. She moved the jaw from side to side or back and forth to unlock it. The joint clicked loudly each time it went out of place. Even talking locked the joint. As the joint caught, she had very sharp pain, which did not radiate to the ear. She had been unable to eat solid food for a week. The condition was worse in the morning, between five and eight o'clock. She had tied her jaws together at night to prevent this morning pain, and used a tube to sip liquid foods. She had also applied ice bags to relieve the swelling of the part.

The left temporomandibular joint was very tender. The patient could open her mouth very slowly to about one inch and often only to one-half inch; the left condyle became prominent and the jaw shifted a little to the right. The left joint cracked roughly and the right one did so to a lesser degree. At frequent intervals, the left joint stuck on mouth opening, at which time she had a good deal of pain. She then moved the jaw from side to side, the joint unlocked, and the pain was relieved. During this manoeuvre, the left joint cracked a good deal. The facial muscles were not atrophic.

No roentgenograms were taken. Meniscectomy was advised, but was not done. On October 28, the jaw was still very painful, but there was less swelling.

CASE 5: A woman, forty-nine years old, was examined on March 4, 1943, because of a sharp pain which had been present in the left temporomandibular joint for five months. There was no known trauma. She found it hard to open the mouth and to chew hard foods. She heard knocking and cracking noises within the joint as she moved it; these had increased recently. She had noticed deviation of the chin to the left on mouth opening. She had worn dentures for from ten to fifteen years. She had rheumatism of the fingers and toes.

The mouth opened one and one-eighth inches, with a marked shift of the jaw to the left. The right condyle showed a good range of motion; motion was limited on the left. Painful thudding noises were felt and heard in the left joint as it moved. On closing the mouth, jaw obliquity was corrected and the chin went to the mid-position. The left joint was tender.

Physical therapy was advised and the patient took a few treatments, but she was not better on August 31. The left joint then showed transient locking as she talked. She was able to unlock the joint and to close her mouth. Operative removal of the meniscus was advised, but was not done.

It may be difficult at times to rule out primary arthritis, as in this case, but it should be remembered that rheumatoid arthritis is usually polyarticular, and that the temporomandibular joint is only one of many joints involved.

INTERPOSITION OF MENISCUS

The interposed meniscus can stop the condyle from leaving its socket. Three groups are described: (1) the untreated joint which is cured spontaneously; (2) the untreated joint in which secondary arthritic changes develop as a result of long fixation; and (3) the fixed joint which is released by operation.

1. *The Untreated Joint which Recovers Spontaneously*

The fixed joint may develop within a few hours or a few days after trauma. This is shown by the following cases:

CASE 6: A woman of thirty-seven, who was seen on March 11, 1943, had been struck on the right jaw two days before. Since then, the jaw had been swollen and painful. She could not chew, bite, or yawn. The right jaw was swollen near its angle; the swelling extended cephalad to the condyle and medially over the face. The right temporomandibular joint was very tender. The mouth opening was only three-quarters of an inch and it was accompanied by cracking of the joint and shifting of the chin a little to the right. Right condylar motion seemed absent, but there was a fair range of left condylar motion.

The roentgenograms were negative for fracture. The right condyle remained in its fossa when the mouth was opened.

CASE 7: A woman of twenty-eight was examined on May 13, 1940, because of pain which had persisted in the left temporomandibular joint since the winter of 1937. She stated that her father frequently struck her on the left side of the face when she was a child, and even up to the age of sixteen. At eighteen, she was hit on the right side of the chin by a drunken companion. She was dazed for a short time, but did not have pain in either joint. She was in an automobile accident in 1933, which dazed her for half an hour. She thought the present disability occurred suddenly, as she was yawning. She opened

her mouth well, but could not close it fully; the joint locked in the partially open position. The mouth opened one-quarter of an inch, and forced opening was painful. This condition persisted for three days, and she could take only fluids and cereals. Thereafter, the joint snapped loudly when she opened and closed her mouth. Lockings occurred at least once a day for about six months. Sometimes the locking lasted half a day, and the joint unlocked in the relaxation of sleep. By locking, the patient meant the inability to open her mouth, although she could close it. She had pain in the left joint as she opened her mouth, but the pain did not radiate to the ear. The chin shifted to the left with each mouth opening.

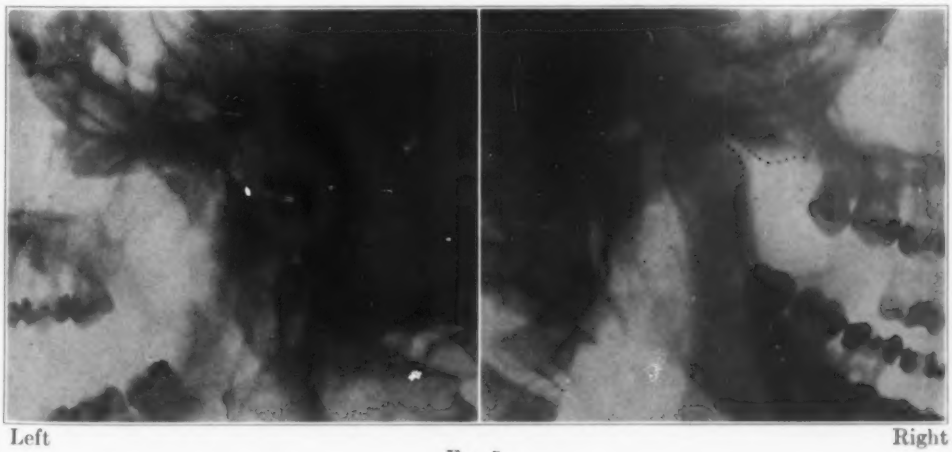
The condition had improved by the next spring and the snapping lessened, giving way to a finer cracking sound. The patient was then well until six or eight weeks before examination, when she again noted cracking of the left temporomandibular joint each time the mouth was opened. She had dull pain on closing the mouth. She could not chew food, but swallowed it whole. The pain was located in front of the ear and radiated to the temple and to the ear canal. She was not deaf nor was salivation increased. There was now no snapping and no locking. Mouth opening and closing were free, and the chin did not deviate. The pain reached its maximum for a period of three or four days, a week before the examination, but at the time of the visit she had no pain except on left lateral movement of the jaw. This pain was slight and radiated to the ear. She could now chew well.

She opened her mouth one and seven-eighths inches, with no deviation of the chin, but as she closed her mouth the chin went to the left and then to the mid-line. After the more prominent right condyle had entered its socket with a thud, the slower left condyle entered its socket without sound. The temporomandibular joints did not crepitate. The left side of the face was somewhat atrophic. The angle of the jaw was 125 degrees. Each joint showed good lateral motion. Roentgenograms, taken elsewhere on May 6, indicated good anterior excursion of each condyle. Anterosuperiorly, the left temporomandibular joint seemed wider than the right, and the condyle rested more posteriorly.

It was evident that this patient had a meniscal tear, which blocked the mouth opening, and that with time she had worn away part of the blocking meniscus to allow free function. She was left with a certain residue of disability by incomplete meniscal erosion, however, so that there was decreased left condylar movement and slight asynchrony. This is a good example of a natural cure, which, as in this instance, usually proves to be incomplete. Surgical cure is quicker and more certain.

Case 8: A man, twenty-eight years old, who was examined on February 17, 1942, believed that his left temporomandibular joint had been slipping out of place for three months. He knew of no specific accident to cause his trouble. The jaw clicked painlessly at least three times a day on mouth opening, and he found it hard to chew solid food. Ten days before the examination, he found himself unable to open his mouth more than an inch. The left joint seemed to go out of place, after he ate a crust of bread, but it slipped into place quickly as he closed his mouth. The same thing happened the morning of examination, but this time the joint did not slip into place. He could not now open his mouth well.

The left temporomandibular joint showed some fullness, but it was not tender. The mouth opening was three-quarters of an inch, with slight deviation of the chin to the right. No movement of the condyles could be felt. The right side of the face was full; the left side was flat.



Left Right

Fig. 5

Case 8. Open-mouth views, taken on February 18, 1942, of both temporomandibular joints. Fixation of the left condyle by meniscal interposition restrained movement of the normal right condyle. The mouth opened three-quarters of an inch. The left condyle did not move at all, but the right one moved to the anterior part of the socket.

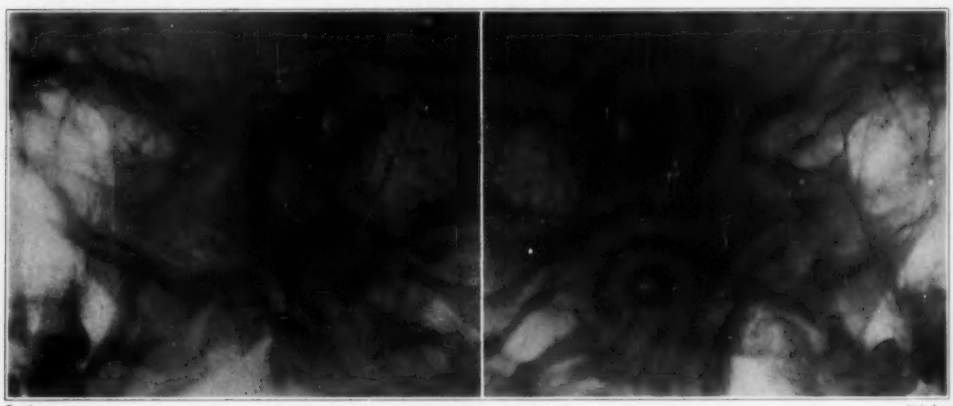
Roentgenograms, taken February 18 with the mouth open (Fig. 5), showed the absence of normal anterior movement of both condyles, which remained in their sockets. In other words, fixation of the left condyle by meniscal interposition restrained the movement of the right condyle, proving that both condyles act as a unit.

FIG. 6-A

Case 10. Photographs taken on April 20, 1940, just before operation. The right temporomandibular joint is fixed in its socket and the chin shifts to the right on mouth opening.

Heat and a soft diet were prescribed. On February 26, he opened his mouth seven-eighths of an inch, and he could open it a little more after the application of heat. He felt tension in the left temporomandibular joint on mouth opening. When seen on April 18, 1943, he had no pain in the left temporomandibular joint except when he opened his mouth for a long time, as in a dental treatment. He opened his mouth one and three-quarters inches, but the chin still shifted to the right. On September 12, 1943, he had no pain and could eat anything. The joint had begun clicking a month before, after nine months of freedom from such clicking. The mouth opened one and three-quarters inches, and the chin shifted at first to the right and then to the mid-line. Again on closing the mouth, the chin went first to the right and then to the mid-line.

A natural cure was anticipated, in view of the short history of disability.



Left Right

FIG. 6-B

Preoperative roentgenograms, taken on April 13, 1940. Roentgenograms of the closed mouth show both condyles in sockets.

Left Right

FIG. 6-C

Open-mouth roentgenograms of the same date. The right condyle is fixed and the left condyle has a little anterior movement.

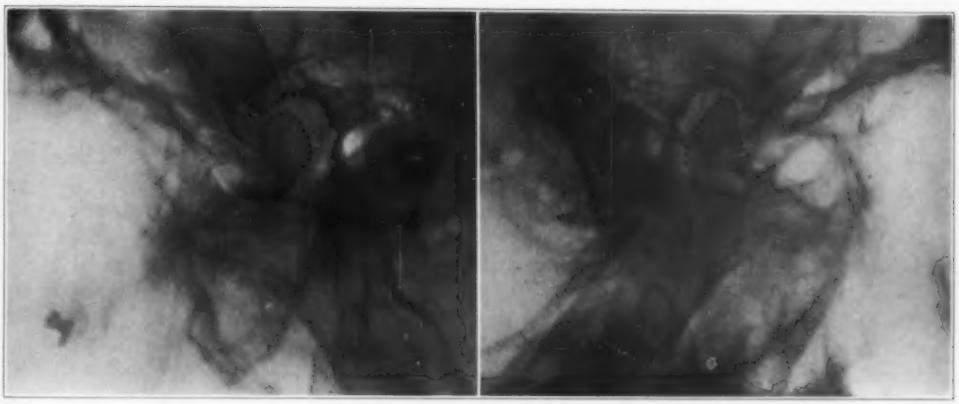
2. *Fixation of the Untreated Joint*

The untreated temporomandibular joint which is fixed in its socket may show secondary arthritic change. The masseter and temporalis muscles become atrophied, either by the effect of direct trauma or through disuse. Hypertrophy of the masseter gives the effect of a square jaw. It is not necessarily associated with disability of the temporomandibular joint.

CASE 9: A man, forty-nine years old, who was examined on April 15, 1940, had been struck on the left jaw some years before by a fist. This caused immediate pain and swelling of the injured part, and three months later he noted clicking of the joint of the left jaw and atrophy of the left side of the face. His chin shifted to the left when he opened his mouth. The left temporomandibular joint crepitated on mouth opening and the condyle moved very little. The right condyle moved forward quite well beneath the articular eminence. The left masseter was markedly atrophic. The angle of each jaw was 130 degrees.

FIG. 6-D

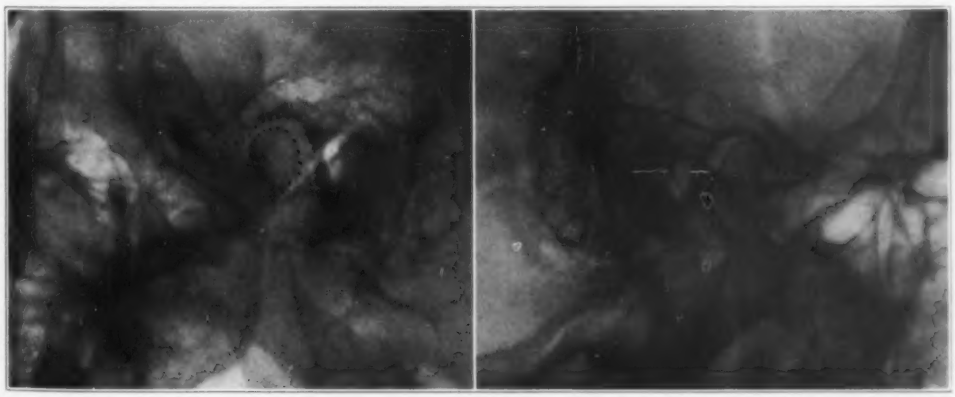
These postoperative photographs were taken on June 12, 1940. Mouth opening is one and one-quarter inches and the chin does not shift.



Left Right

FIG. 6-E

Postoperative roentgenograms, taken on June 3, 1940. The open-mouth view shows some forward advance of the right condyle, but less than the left.



Left Right

FIG. 6-F

Closed-mouth view.

Roentgenograms, taken on May 24, showed narrowing of the joint space on the left, with flattening of the condyle. These changes are indicative of secondary arthritis. On mouth opening, the left condyle moved to the articular eminence, while the right condyle was anterior to it. The left condyle showed more motion by roentgenogram than appeared clinically.

3. *Operative Treatment of the Fixed Temporomandibular Joint*

CASE 10: Mrs. F. M., nineteen years old, was first examined on April 12, 1940. She had been struck a hard fist blow on the right jaw, three and one-half months before. She felt as if something went out of place, and at dinner that evening the jaw clicked painlessly each time she opened her mouth. She opened her mouth halfway without difficulty, the jaw clicked, and the mouth could then be opened wide. A month after injury, a dull pain was felt in the jaw; this pain radiated down the neck. She thought the chin at that time deviated to the left on mouth opening. The jaw was manipulated under anaesthesia by another physician about that time, and was strapped for a week. The click disappeared after manipulation, but she then became unable to open her mouth. Apparently, after manipulation, the loose meniscus became fixed, so that excursion of the anterior condyle was blocked. She noted overlapping of the lower teeth by the upper teeth. She could not chew hard foods or large boli of food. Because of a carious left molar tooth, she chewed her food mainly on the right side, and the left temporomandibular joint became more painful than the right.

The chin was questionably deviated to the right on mouth opening. Right condylar motion could not be felt, but there was excursion of the left condyle, which was limited by stiffness of the right temporomandibular joint. The mouth opening was three-quarters of an inch; the right jaw grated (Fig. 6-A). A left upper molar tooth was carious, and this was removed.

Roentgenograms taken on April 13, 1940, (Figs. 6-B and 6-C) showed no excursion of the right condyle with the mouth open, and only slight anterior excursion of the left condyle. The right joint space was cloudy, a finding which had been absent in roentgenograms taken on December 11, 1939.

The right joint became "frozen" by meniscal interposition after the manipulation, and later by ligamentous contracture. The fixation of the right joint prevented the full excursion of the left condyle.

On April 20, under local novocaine infiltration anaesthesia, the right temporomandibular joint was approached by a modified Burdick incision. The ear part of the incision overlay the pinna and the vertical arm crossed the temporomandibular joint. This made almost all of the incision lie in the hairline. The zygoma was defined, and then the temporomandibular joint. The striking finding was the thickening of the capsular and ligamentous tissues, which bound the joint firmly. These tissues were excised, as was a loose meniscus. After this had been done, the mouth could be opened wide and the condyle rode normally beneath the articular eminence. The wound was closed, and a Barton bandage was applied. A small venous ooze from the ear was noted, and the ear was packed with sterile cotton.

The postoperative course of this patient was uneventful; the only complicating factor was a tear through the membranous part of the right external auditory meatus, which caused slight difficulty in hearing and was responsible for buzzing and ringing. The tear followed the use of a sharp-pointed automatic retractor. Twice, a spicule of bone was extruded through this ear opening. The ear had healed by June 10, the canal was patent, the tear healed, and hearing was normal. The patient chewed paraffin and gum and the return of motion was rapid (Fig. 6-D).

Roentgenograms made on June 3, 1940, (Figs. 6-E and 6-F) showed slight motion of the right condyle and fair motion of the left, with the condyle almost riding the eminence.

The patient's last visit was on January 10, 1941. At that time she could eat all hard foods. She had some pain in the region of the right temporomandibular joint in rainy weather. The mouth opening was one and three-eighths inches. The condyles could not be felt. Slight hypaesthesia was still present in the right temporal area. She could move the jaw to the right more than to the left, both with the mouth open and closed.

CASE 11: Mrs. E. O'C., a woman of forty-six, was first examined on January 14, 1944. She had been struck a very hard blow by a closet door a year and a half before, in the region of the right temporomandibular joint. The joint area remained sore for at least six weeks. Clicking began about two or three months after the injury, especially when she was eating. Locking occurred every few weeks, with the mouth partly open. Since the accident, she believed that the right lower teeth were wearing away "at a slant" because of an unequal bite. A right upper molar had been extracted in the spring of 1943. Other right molar teeth, both upper and lower, had been extracted twenty-five years before. With a little care, she had been able to eat everything, and she had been able to open her mouth fully.

She was chewing candy a few days before Thanksgiving of 1943, when the right temporomandibular joint clicked two or three times, and an hour later she could not open her mouth more than three-quarters of an inch. A meniscal derangement was diagnosed by her physician. An attempt to open her mouth had been made four weeks before, under intravenous anaesthesia, but this made the disability worse. After manipulation, she could open her mouth only one-half inch. For the two weeks before

examination, she complained of soreness in the right joint, with pain referred to the ear. She could eat only soft or mashed foods.

On mouth opening, the interdental distance was three-eighths of an inch. Tenderness was present over the right temporomandibular joint. She could move her jaw to the right much better than to the left. The chin shifted to the right on mouth opening, and this shift was also seen with the mouth closed (Fig. 7-A). Roentgenograms confirmed the clinical diagnosis that the right condyle was "frozen" in its socket (Figs. 7-B and 7-C).

On January 21, 1944, the right joint was explored under local infiltration anaesthesia with novocaine. The capsule may have been slightly thickened. The meniscus was torn in two, and the anterior part had been displaced medially. When this part of the meniscus had been removed, she opened her mouth well, with no obliquity and with equal lateral motion.

The postoperative course was good. There was swelling and ecchymosis of the loose areolar tissues beneath the right eye ("black eye"), and a subconjunctival hemorrhage in the right eye. This subsided quickly. The right side of the forehead did not wrinkle, presumably because of retractor pressure.

The patient received physical therapy. Her progress was slow, possibly because the most anteromedial part of the meniscus or ligament was not resected. Mouth opening on February 18, 1944, was three-quarters of an inch, with a slight shift of the chin to the right. On March 22, it was seven-eighths of an inch, with the chin shifting slightly to the right. Wrinkling of the right side of the forehead was returning. On April 5, mouth opening was one inch, but the involved joint was still painful at times. On June 21, she could open her mouth one and one-quarter inches, and there was a slight shift of the chin to the right. Wrinkling of the right side of the forehead was now present. Several of the lower left teeth had been removed during the previous month, and she had to chew on her right side. She rightly attributed the increased motion of the joint to this fact. Proper dentures were made after operation to give proper chewing and hence better joint motion. The involved joint was now not painful, but it was a little stiff in the morning. Roentgenograms (Figs. 7-E and 7-F), made on January 5, 1945, showed an excellent range of motion of both condyles.

On microscopic study, the meniscus showed degeneration and, at one point, a defect with some evidence of repair. A tiny fragment of parotid-gland tissue was seen in the tissues studied; it was obtained from a part of the parotid gland which enters the posterior part of the joint.

TRUE DISLOCATION

It has been stated that the temporomandibular joint is the only joint which dislocates normally. The condyle leaves its socket and can return to it at the will of the patient. In this sense, it corresponds with the so-called habitual or relaxed dislocation of other joints, but in other joints the movement is in excess of normal. When the condyle cannot return to its socket by meniscal interposition, an irreducible dislocation exists. This is a true dislocation, in contrast to the normal or false dislocation of the condyle.

CASE 12: A woman of thirty-four fell down two flights of steps on February 21, 1940, injuring her head, left leg, and right shoulder. Her important complaints on April 30 concerned the right supraclavicular region, which was painful and swollen, and the right shoulder. She had noted no trouble with the jaws before the accident.

The examination showed a dislocation of the sternal end of the right clavicle, bilateral very large cervical ribs, sprain of the back and of the cervical spine, and strain of the right shoulder. She opened her mouth in a jerky manner; both condyles were more anterior than usual and the chin deviated to the right. Each condyle was prominent and a depression was felt posterior to it. In mouth closing, each condyle retreated into its socket with a thump, as if overcoming a bony obstacle. This was followed by a click in each jaw, which was louder and more painful on the left. The pain was referred to the ear. Tenderness was present on the left side in the space between the condyle and the mastoid process. The angle of the jaws was 125 degrees, and the patient could open her mouth slowly to one and three-quarters inches.

Roentgenograms made on May 6 showed that the left condyle did not enter its socket in the closed-mouth position and that it was irreducibly dislocated anteriorly by meniscal block. The neck showed marked limitation of lateral motion, but roentgenograms of this region were negative. No treatment was given.

The injury of the temporomandibular joints is part of a more diffuse injury to the head and neck. This association is so common that the function of these joints is tested in any case of severe blunt trauma to the head and neck.

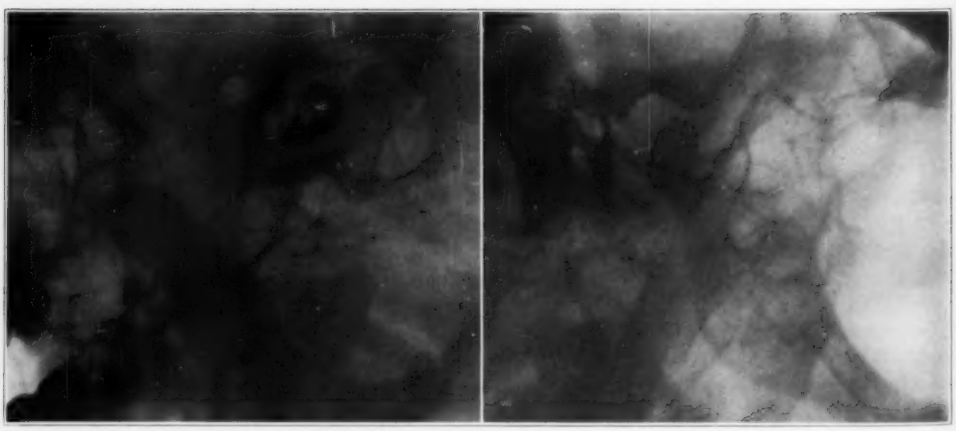
CASE 13: Mrs. K. R. V., a woman of twenty-seven, was first examined on November 17, 1939. On April 15, 1937, she had struck the left side of her head against a bus seat, as the bus stopped suddenly.

FIG. 7-A

Case 11. Photographs taken on January 20, 1944. The chin shifts to the right on mouth opening, because the left condyle moves more easily and more anteriorly. Right lateral movement is better than left lateral motion. A clinical diagnosis of fixation of the right condyle in its socket was made before roentgenograms were taken.

Left Right

FIG. 7-B



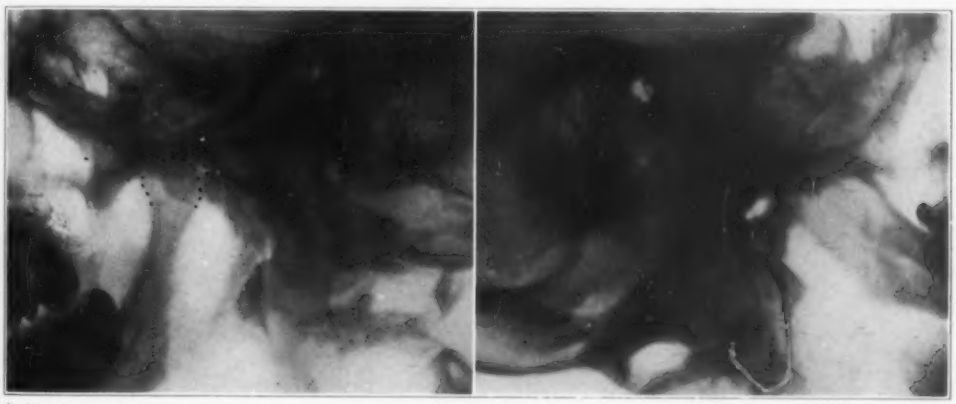
Left Right

FIG. 7-C

Closed and open-mouth roentgenograms, taken on January 19, 1944, two days before operation. Both condyles rest in socket in the closed-mouth view; in the open-mouth view they move to the anterior part of the joint, but do not go under the eminence. The movement of the normal left condyle is restrained by the blocked right condyle. Mouth opening does not exceed three-eighths of an inch.

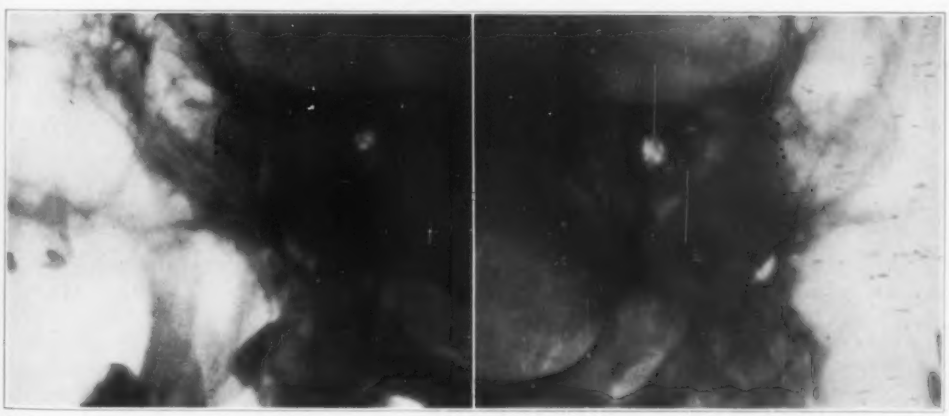
FIG. 7-D

Postoperative photographs, taken on January 30, 1945. Patient had no trouble with the jaw joint after operation. Mouth opening was one and five-eighths inches, and both condyles moved well. The right condyle grated a little on motion. The chin did not deviate on opening the mouth, and lateral motions were equal.



Left Right

FIG. 7-E



Left Right

FIG. 7-F

Roentgenograms of January 5, 1945, closed and open-mouth views, confirmed the excellent anterior range of both condyles. The right condyle was under the eminence and the left condyle was anterior to it.

FIG. 8-A

Preoperative photographs, taken on November 4, 1944. J. C., a woman, twenty-four years old, had had her head snapped backward on September 5, 1944, as a street car hit her automobile. She was placed in head-and-neck traction and a Calot jacket was applied on September 29, 1944. During the period of traction, she complained of pain in the right temporomandibular joint. The pain and inability to open the mouth increased rapidly, so that a meniscectomy was done on November 6. The capsule was thickened and the meniscus was displaced anteromedially. Not all of the meniscus could be removed. She had transient paralysis of the right side of the forehead, with absence of wrinkling. Photograph shows the range of mouth opening and the lateral movements allowed. The roentgenograms proved that both condyles did not leave their sockets on mouth opening; fixation of the right condyle restricted the movement of the left condyle. This case illustrates the fact that injury to the head and neck is not infrequently associated with injury of the temporomandibular joint.

FIG. 8-B

Postoperative photographs, taken on February 23, 1945. On March 9, the patient could open her mouth one and one-eighth inches. There was a little deviation of the chin to the right, by greater forward motion of the left condyle. Right lateral motion exceeded that on the left, but both were restricted. The right condyle was slightly tender.

The injured half of her face quickly became swollen. She was told that the left jaw was dislocated, and this dislocation was apparently reduced four days after the injury. Dislocation recurred, and attempts at reduction were made on four different occasions over a period of several months, without complete success. Before the first reduction, she opened her mouth with discomfort and could not chew solid foods.

The patient stated that the jaw still dislocated many times a day on opening the mouth wide. She had a dull pain in the left temporomandibular joint after chewing, and she could not chew hard foods. When chewing on the right side, there was an annoying, painful clicking of the left temporomandibular joint. She could close her mouth, but had noted altered occlusion of her teeth, with a shift of the mandible to the right. The swelling of the angle of the affected jaw still persisted. More recently, she complained of a deep clicking in the left ear.

The lower jaw did show a lateral shift to the right, with malocclusion of the teeth; the upper teeth overlapped the lower set. The left half of the face seemed broader and flatter than the right, and the left half of the mouth was wider than the right, especially on mouth opening. The left mandibular condyle was tender and prominent, and slipped forward with a click. Mouth opening increased the

mandibular deviation. On mouth closing, the condyle seemed to slip into place. The patient was able to thrust the jaw forward and also backward. In the dislocated position, the angle of the jaw was placed more posteriorly than normal. The temporal area was tender, and the molar bone and zygoma were prominent. Roentgenograms showed that, in the closed position of the mouth, the left condyle was at the anterior part of the socket and, on mouth opening, the condyle moved forward normally (Fig. 11-A).

On January 16, 1940, under local novocaine infiltration anaesthesia, the temporomandibular joint was exposed by the Burdick incision. After the exposure of the zygomatic process, the temporomandibular joint was easily identified. Care was taken to keep within the safe triangle, described by Morris. *The capsule of the joint was thin and loose.* The loose meniscus was removed in several pieces. The articular eminence was small and, even after removal of the meniscus, the jaw seemed to show undue mobility. An anterior block was made, as described by Mayer, and a half-inch piece of zygoma was used as the graft. The eminence was split horizontally and pried down, as in a shelf operation for an inadequate acetabulum,* and a bone graft was inserted into the gap. A plaster helmet was applied after the wound had been closed, and was worn for six weeks.

The operation assured a better articular eminence and provided an anterior buttress, which, it was felt, would be mechanically sufficient after healing to prevent the anterior dislocation of the condyle. The postoperative course was good, except for considerable swelling of the left side of the face, including the eye. The facial nerve was not injured.

FIG. 9-A

Preoperative photographs of M. V., a male, aged twenty-six, taken when he was examined on February 1, 1945. He was struck a fist blow in the region of the right temporomandibular joint, five months before he was first examined. The right joint gave evidence of pain rather than of restriction of motion, since the mouth opening was from one and one-eighth inches to one and one-half inches. Lateral motion was more restricted on the left than on the right, but both were painful.

FIG. 9-B

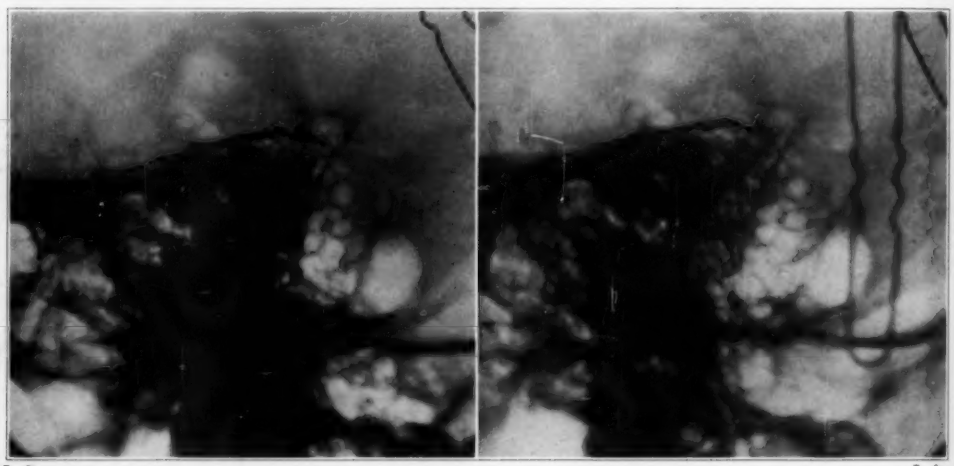
Operative removal of the meniscus and resection of the thickened capsule were done on February 16, 1945, with local anaesthesia. These postoperative photographs were taken on April 26. The patient had no complaints.

* This method was suggested by A. Schmier, M.D.

At the examination on April 19, 1945, the patient could open her mouth about one and three-eighths inches, but the chin deviated a little to the left, indicating greater motion in the right temporomandibular joint. Both condyles could be palpated readily, but the left moved less than the right. Right lateral motion of the jaw was less than left lateral movement in the open-mouth position. The bite was good and she could chew hard foods. The left joint crepitated a little on motion. The left side of the face was fuller than the right. Roentgenograms showed normal excursion of the right temporomandibular joint, but the left condyle remained in its socket on mouth opening, partly due to fibrosis and partly because of the bony block with reverse of the mandibular shift and restraint of right lateral movement. The anterior bone block was well developed (Fig. 11-B).

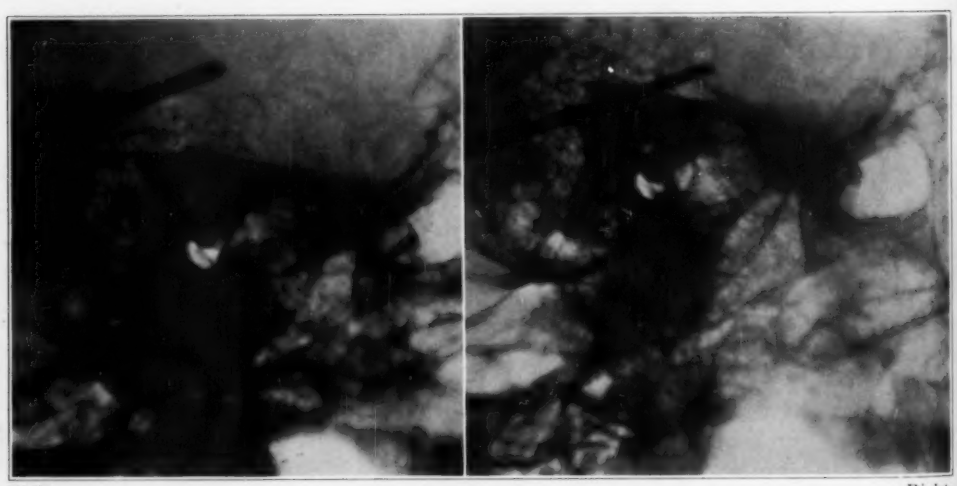
The bone-block operation is not physiological, since it restrains full anterior movement of the condyle. The removal of the meniscus allows the replacement of the condyle in its socket and this is all that is needed. The shelf procedure does not seem worth while.

CASE 14: On February 12, 1942, a man of forty-four fell a distance of twelve feet to the ground from a broken ladder and struck his chin against the ladder as it lay upon the ground. The chin was lacerated



Left Left

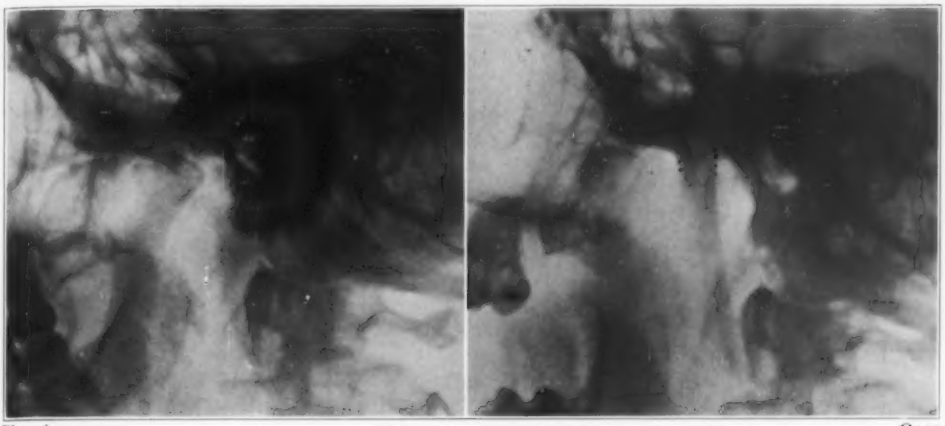
FIG. 10-A



Right Right

FIG. 10-B

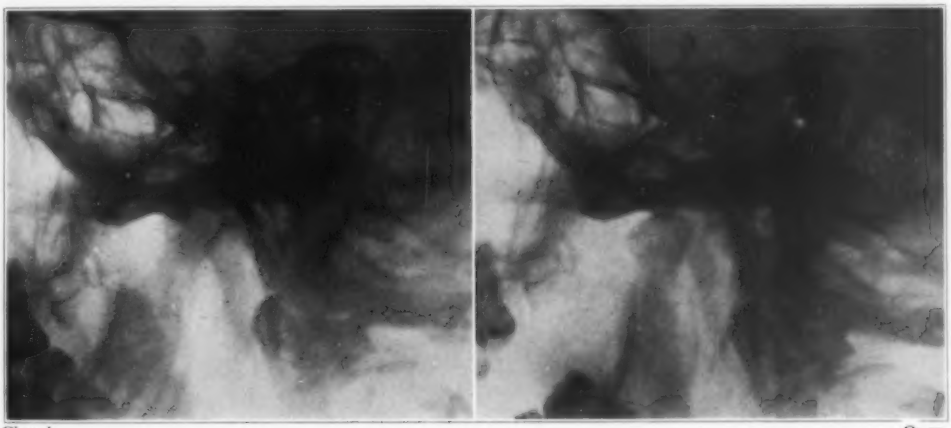
A woman of seventy-five displaced both condyles anterior to the articular eminence while yawning, six days before she was seen in the emergency room of the Hospital for Joint Diseases. This is the only instance in this series in which both condyles were dislocated. The roentgenograms show both condyles to be anterior to the eminence, as in normal full-mouth opening, but the significant difference from the normal is that the condyles could not retreat into their sockets on mouth closing.



Closed Open

FIG. 11-A

Case 13. Roentgenograms of the left temporomandibular joint, closed-mouth view, dated November 17, 1939, show the condyle to be displaced to the anterior part of the socket. With the mouth open, good anterior movement of the condyle is disclosed. The right condyle moves normally.



Closed Open

FIG. 11-B

Closed-mouth view of the left temporomandibular joint, dated April 1, 1940, shows the condyle in its socket. Open-mouth roentgenogram shows that the condyle moves a little, but does not leave its socket because of the bone block.

FIG. 11-C

Postoperative photographs taken on April 19, 1945, more than four years after operation. Patient had no complaints. Mouth opening was a little more than one and one-quarter inches; the chin deviated to the left, because left condylar motion was restricted by the bone block. Right lateral motion of the jaw was less than left lateral motion, for the same reason.

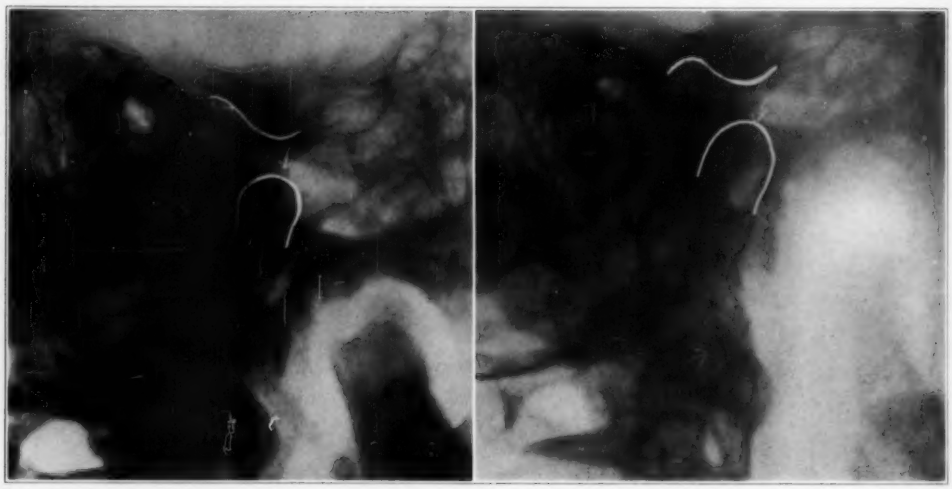
and the lower front teeth were lost. The lost teeth were later replaced by a denture. The patient had a cerebral concussion, and bled from the left ear for four days. He was in a hospital for thirty-three days.

He stated that, while in the hospital, he could not open his mouth well nor could he chew solid food. He complained of localized, intermittent pain in the left temporomandibular joint, made worse by yawning or by chewing hard food. He had to soften his food by soaking it in water. The left temporomandibular joint clicked at times. He denied previous injury to his jaw.

He was first examined at this Dispensary on December 16, 1942. The left temporomandibular joint

FIG. 12-A

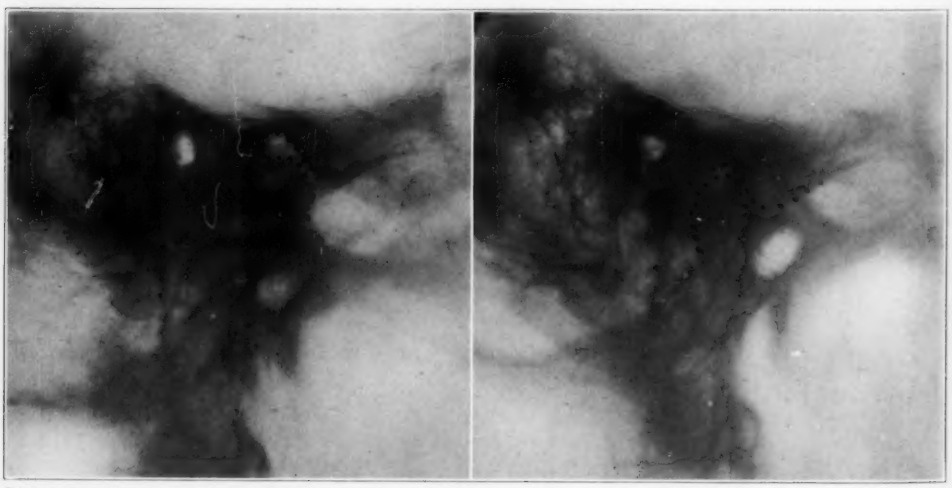
Fig. 12-A: Case 14. This man had an irreducible anterior dislocation of the left condyle. Mouth opening was greatly restricted. The shift of the chin is not well seen in the photographs (taken February 12, 1943).



Left, closed Left, open

FIG. 12-B

Preoperative roentgenograms (made December 16, 1942) of the left temporomandibular joint. In the closed-mouth view, the left condyle is seen in the anterior part of its socket, and it is fixed in this position. (Illustration has been reversed.)



Right, closed Right, open

FIG. 12-C

The normal right jaw shows restriction of forward excursion of its condyle.

was tender, mouth opening was restricted, and there was a little deviation of the chin to the left. No clicking was heard as he opened and closed his mouth. Left lateral motion of the jaw was limited, but right lateral motion was full and was associated with clicking of the right temporomandibular joint.

Roentgenographic examination of each temporomandibular joint, with the mouth open and closed, disclosed an irreducible, anteriorly placed left condyle (Fig. 12-B). It moved forward a little as the mouth opened. The condyle seemed flatter than normal. The right condyle showed restricted anterior excursion, on mouth opening, by anterior fixation of the left condyle.

Baking and massage were given for the relief of pain. On February 13, 1943, a year after the injury, the anteriorly displaced meniscus was removed under local novocaine infiltration anaesthesia, by a modified Burdick incision. The superficial temporal vessels were ligated. *The ligamentous tissues and capsule of this joint were thickened, scarred, and adherent.* The zygoma showed a small exostosis, inferiorly. After the resection of scarred capsular tissue, the anteriorly displaced condyle was exposed. The meniscus was displaced anteriorly and lay between the condyle and the articular eminence. The fossa was narrow and was filled with scar tissue. The condylar cartilage was grayer and more opaque than normal. The scarred tissues were removed and meniscectomy was done. It was only after division of the shortened anterior ligament that the condyle entered its socket. The range of joint motion was now much greater than before operation. After wound closure, it was noted that the left side of the forehead wrinkled less than the right side. This was attributed to retractor pressure on the branch of the facial nerve supplying the forehead.

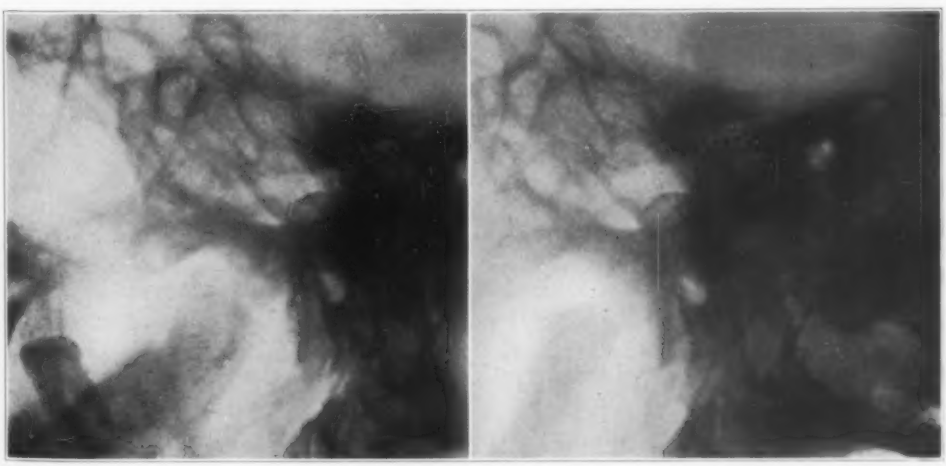
The patient's postoperative course was not eventful. Five weeks after operation he could open his mouth one and three-eighths inches, without deviation of the chin, and this range of motion has not increased. He has recovered wrinkling of the entire forehead. He has no pain in the joint and can chew hard foods.

Postoperative roentgenograms showed correction of the dislocation. The left condyle rested within the socket in the closed-mouth position, and advanced just short of the eminence in the open-mouth position; the right condyle advanced a little farther.

On July 14, 1944, the patient stated that the left temporomandibular joint had gradually become stiff so that he could not bite a hard piece of bread. He opened his mouth one and one-eighth inches, with no shift of the chin. Left condylar motion seemed less than right. Each condyle was in its socket and had little anterior excursion.

FIG. 12-D

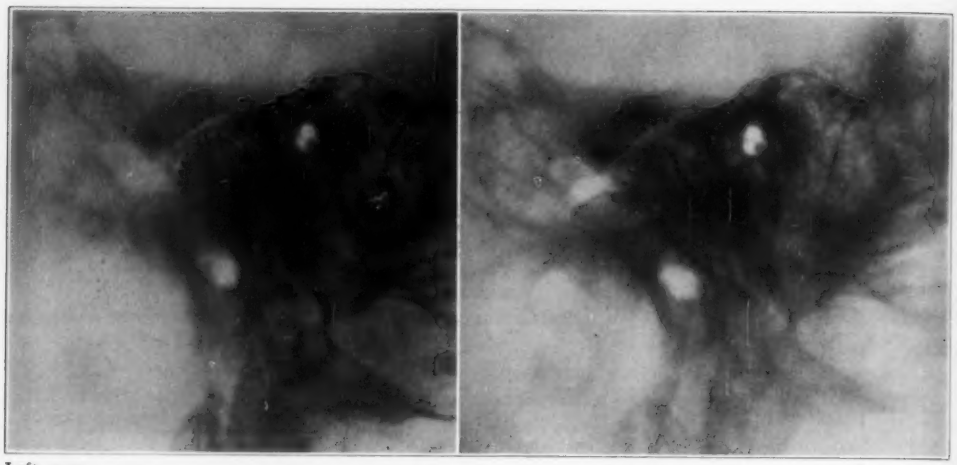
The thickened capsule and ligaments of the left temporomandibular joint, as well as the meniscus, were resected on February 13, 1943. The photograph shows mouth opening on April 17, 1943.



Closed Open

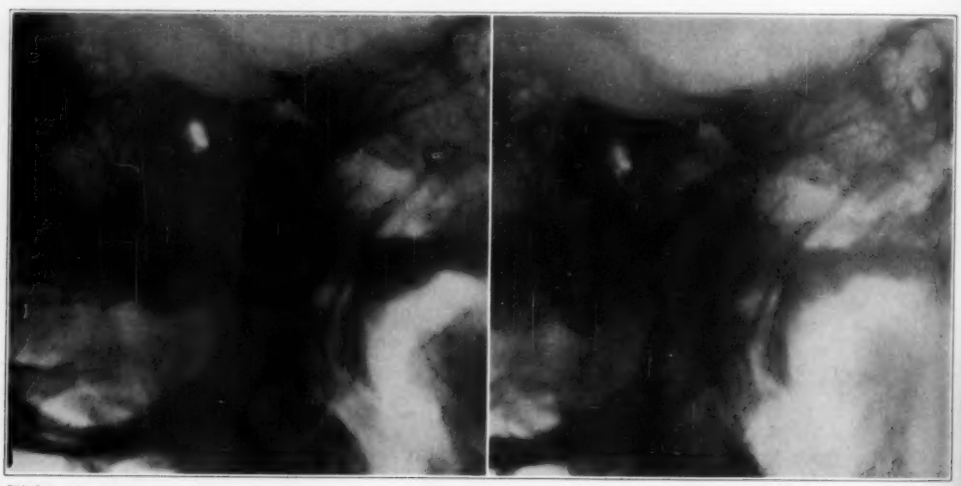
FIG. 12-E

Postoperative roentgenogram of the left temporomandibular joint, taken on September 3, 1943. The condyle is in its socket in the closed-mouth view. The distorted right condyle is seen near it. In the open-mouth view, the condyle moves to the anterior part of the socket.



Left, open Left, closed

FIG. 12-F



Right, open Right, closed

FIG. 12-G

Roentgenograms taken on August 15, 1944. The condyles are in the sockets and, on mouth opening, move to the anterior part of the joint.

In one case, it should be noted, the capsule was thin and loose, whereas in the other case it was thickened, scarred, and adherent.

TECHNIQUE OF OPERATION

The operation should be done under local anaesthesia for two reasons: first, to see if normal mouth opening is restored after resection of the blocking meniscus and thickened capsule and ligaments, and second, to have the reassurance that the branches of the facial nerve have not been injured. The drapes are arranged so that the patient's face is examined readily.

A modified Burdick incision is used (Fig. 13). It begins just above the pinna, runs along the zygoma for less than half an inch, and then dips distally for about half an inch. The length of the incision is about one inch to one and one-quarter inches. The tragus and the zygoma are the landmarks, and the incision must stay within the safe area which Morris has stressed. This is bounded posteriorly by the superficial temporal vessels and

the auriculotemporal nerve, which may be sacrificed, and anteriorly by the facial-nerve branches to the forehead and eye. The subcutaneous and fascial tissues are thick and fibrous, and incision is made through them to the zygoma, beneath the posterior part of which the condyle lies. The capsule of the joint is identified, opened, and, if necessary, resected. The meniscus is next identified; the patient opens and closes his mouth for orientation. When the meniscus is loose or torn, it is displaced anteromedially, and this corner of the joint must be properly freed of thickened anterior ligament or blocking meniscus. The internal maxillary artery lies under the neck of the mandible, and runs medially and horizontally. It is usually separated from the mandible by the thickness of the pterygoideus externus. After satisfactory resection of the ligaments and meniscus (a procedure which the operator may find difficult because of oozing of blood, and which he may control by packing the posterior half of the joint), the mouth should open well and the condyle should advance and retreat almost normally. The wound is closed in layers and a Barton bandage is applied. Active movement of the jaw is begun within a week after operation. The chewing of gum or paraffin is encouraged.

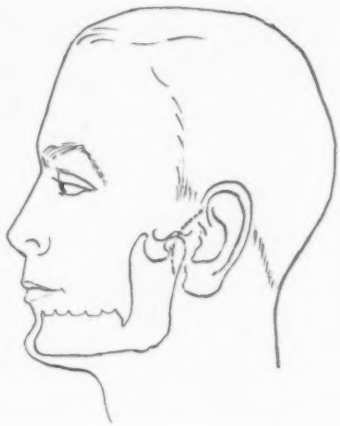


FIG. 13

Modified Burdick incision is shown.

The meniscectomy should be as complete as possible. The limitation of full movement is probably due to the fact that the meniscus, especially its most anterior and medial part, cannot always be fully resected.

CONDYLAR ASYNCHRONISM

A group of unusual cases are described, in which condylar asynchronism is noted.

FIG. 14

Case 15. This woman had a traumatic hemiatrophy of the left side of the face, with asynchrony of condylar movement. Photographs taken June 22, 1940.

FIG. 15-A

Case 16. This young woman had an extensive naevus flammeus of the left side of her face and forehead, and glaucoma of the left eye. To this syndrome was added left condylar hypertrophy with palatal and dental inclination. The chin was shifted to the right, both with the mouth open and closed, because of the condylar enlargement.

Hemi-Atrophy of the Face and Asynchronism of Condylar Movement

CASE 15: A woman, seventy years old, struck the left side of her face against a rock at the age of one year. Since then, there had been atrophy of that side of the face (Fig. 14). This caused no functional disability. The two sides of the face were quite different, and the right half appeared younger than the left. The atrophy included the temporalis muscle (with depression of the temple) and the frontalis muscle. There was no facial-nerve palsy. The left mandibular condyle seemed a little deformed and the

Left Right

FIG. 15-B

Left Right

FIG. 15-C

Views of the temporomandibular joints, taken on May 13, 1940, with the mouth closed and open. The closed-mouth view (Fig. 15-B) shows flattening of the left condyle, with an anterior beak. The left condyle is larger than the right; it has moved more anteriorly than its mate.

ascending ramus of the mandible was felt throughout its entire extent by the absence of the covering masseter muscle and parotid gland. Mouth opening was full. The chin deviated to the right as the patient opened her mouth, and swung again to the mid-line on full-mouth opening. The left temporomandibular joint crepitated as it moved. On mouth closing, a reverse path was followed.

To the syndrome of unilateral condylar hypertrophy and palatal and dental inclination, may be added that of naevus flammeus and glaucoma.

Naevus Flammeus, Glaucoma, and Condylar Asynchronism Caused by Congenital Hypertrophy of the Condyle on the Side of the Naevus

CASE 16: A woman, twenty-eight years old, opened her mouth two and one-eighth inches; the chin deviated to the right as she did so. The left temporomandibular joint crepitated on movement, but the right one was silent. Both condyles moved beyond the eminence, the left a little more than the right. The left condyle felt larger than the right one.

The left eye was glaucomatous and was operated upon at an undetermined time before examination in 1940. The large naevus is shown in Figure 15-A. The left side of the face was hypertrophic because of this vascular tumor. The left upper lip was enlarged and was inclined downward and laterally. There was similar obliquity of the hard palate. The left upper teeth overlapped the lower ones and were inclined downward and laterally.

Dystonic Asynchronism

In dystonia, asynchronous condylar motion may be noted when the muscles of the head and neck are involved. This may be attributed to spasticity of the pterygoideus externus and of the other jaw muscles.

CASE 17: A boy of eighteen had a moderate form of generalized dystonia. There were occasional twisting movements of the head and neck to the right or left. He found it difficult to hold the head in the mid-line. The neck was elongated, or giraffe-like. His speech was dysarthric. He opened his mouth fully, but there was left lateral deviation of the jaw. The asynchrony of condylar motion was shown by more rapid advance of the right condyle. In mouth closing, the left condyle retreated first. The left mandible was less developed than the right. He moved the jaws from side to side easily, with some exaggeration over the normal.

Other Conditions

Disturbances of the temporomandibular joint also occur in malocclusion of the teeth, in prognathism in which the condyle is brought forward, and in recession in which it is placed more posteriorly. The edentulous mandible shows a posterior condylar position and relative lessening of the angle of the jaw.

NOTE: Cases 5, 15, and 17 were seen on the Service of Dr. Leo Mayer, Hospital for Joint Diseases, New York City.

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A REVIEW OF THE INCEPTION AND DEVELOPMENT OF A TYPE OF REPARATIVE SURGERY ADAPTED TO BODILY MECHANICS

BY ROYAL WHITMAN, M.D., NEW YORK, N. Y.

This exposition, to justify its title, must include my initiation to Orthopaedic Surgery. This was in 1882 when, as a House Surgeon at the Boston City Hospital, I assisted Dr. Bradford in the resection of a tuberculous hip joint.

The outlook for further progress was not encouraging, since the only clinic available for practical training was that of the Children's Hospital, then in the embryo stage of its development, which had no occasion for my services.

Thus for lack of other opportunity, I began, perforce, what was to become a perennial course of self-education, based on the observation of the gait and posture of the walkers on the street, in an attempt to interpret the instinctive adaptations to locomotive disability and to deformity. This ambulatory, and what might be termed peripheral, approach to the subject proved to be greatly to my advantage, since it opened a new therapeutic field, capable of progressive and productive development.

My first utilization of this material was on the question of the spontaneous outgrowth of deformities of the lower extremities in childhood. This was the generally accepted impression, which I disproved, at least from the aesthetic standpoint, by tabulating the proportion of the adolescent and adult walkers who had not outgrown childhood deformities.[2] This indicated the advantage of corrective treatment, while the bones were in the plastic stage, by "means at the command of mothers and nurses".

The second essay in adaptive therapeutics was of far greater importance, since it was the first of consecutive contributions to the type of surgery under review. A young woman, disabled by painful flat feet, was sent to me for treatment. I had never heard the subject mentioned in medical school, and the textbooks gave it scant consideration. The deformity was likened to a broken bridge, which might be made serviceable by supporting it from beneath.

In my inexperience I consulted a member of the staff of the Children's Hospital, which had added a brace shop to its equipment, as to the proper procedure. He instructed me to make an outline tracing of the feet and to send it with a pair of shoes to the hospital, where sole plates would be constructed. This episode represents fairly the therapeutic standing of an important disability, often mistaken for rheumatism, and otherwise relegated to the care of cobblers and mechanics.

At this unsatisfactory juncture, I came upon a report of the dissection of a flat foot by Humphry. This was enlightening, since it demonstrated clearly that the deformity was not the result of a direct breaking down of the arch, but was incidental to a subluxation of the astragalus on the os calcis, which deflected the strain of weight-bearing and locomotion to the inner border of the foot. Thus it appeared that the primary and significant physical sign of the disability was not the lowered arch, but the loss of the normal incurvation of the inner contour of the foot, which implied a persistence of the passive attitude of abduction. The flat foot, therefore, was a later stage of a progressive disability, of which the predisposing and exciting causes were improper postures in standing and in locomotion, of which my observation of walkers on the street had furnished abundant evidence. It was obvious, therefore, that the essential of effective treatment was not the propping up of a broken arch, but the restoration of the normal relations of the leg and foot.

To make this conclusion operative, a leverage brace was modeled on a plaster cast of the corrected foot. It was designed to provide lateral rather than vertical support, thus to check deformity at its source and, by suggestive pressure on the inner aspect of the

foot, to prevent the predisposing outward rotation of the limb. It served, therefore, as contrasted with sole plates and stiffened shoes, as a positive factor in reconstructive treatment, since by maintaining the proper relation of the power of the fulcrum, locomotion was utilized as a recuperative exercise. When the normal posture enforced by the brace had become automatic, the brace was discarded.

This essay on the positive treatment of a neglected disability and on its prevention by the timely recognition of its predisposing causes was published [3] and I was invited to present the subject to The American Orthopaedic Association. This society, the first of its class, had been organized under a temporary truce between its factions, in order to qualify for membership in the Congress of American Physicians and Surgeons, to be held at Washington in the autumn of 1888.

The admission of The Association to the Congress as an entity was a tacit recognition of its emancipation from the restrictions of scope and method with which the term "orthopaedic" was associated. It was therefore a point of departure from which progress in normal and consecutive development may be reckoned, — progress which eventually transformed an ill-conditioned and factitious specialty into an integral branch of surgery. The meeting had also a reciprocal influence on the development of what may be termed adaptive surgery, for it was evident that a further application of the principles that had proved effective in the reconstructive treatment of the flat foot required a better understanding of bodily structure and function.

I undertook, therefore, an intensive study of anatomy, and tested my acquirement by passing the examination for membership in the Royal College of Surgeons. On my return from England, I migrated to New York, where orthopaedic surgery had been first defined by Mott in 1841, where Sayre had established its first professorship in 1859, where Knight had founded the first hospital of its class in 1863, where The American Orthopaedic Association had been organized in 1887, and which was the storm center of the controversy as to whether mechanical or operative surgery should be the dominant factor in its title.

Immediately upon my arrival, I joined the staff of the Hospital for the Ruptured and Crippled. I was assigned to the Out-Patient Department, which in the number and variety of its patients offered a striking contrast to my past experience; for it represented the development of Knight's system of "surgico-mechanics", which included every physical disability symptomatically amenable to bandaging and bracing, irrespective of its character or of the age or sex of the patient. Thus, at this juncture, a definite purpose, an increased capacity for interpretation, and abundant material provided a dependable basis for the consecutive development of the type of surgery with which this paper is particularly concerned.

Naturally, my first interest was in establishing a comprehensive treatment of the so-called flat foot for which the Outdoor Department provided a fertile field. In 1889 this condition was not noted in the Hospital report. In 1929, approximately 5,000 new cases of the disability were recorded. The construction of positive supports had become the chief industry of the mechanical department, and treatment, designed to restore normal function, was the most distinctive feature of the Service.

In the meantime, my interest in observing and interpreting peculiarities of gait brought to light fracture of the hip in childhood. Thus I was enabled to demonstrate the technical efficiency of anatomical mechanics in a class of cases in which the treatment of the fracture was the only consideration.[3]

In the development of the treatment in a comprehensive sense, I had the further advantage of an approach from the standpoint of hip disease, with which it had much in common. Thus the plaster spica, the changes in posture, the interpretation of the physical signs as indicating the progress of repair, and the use of the caliper hip brace in cases in which early locomotion was required were adaptations to the fracture and the patient which made effective treatment practicable and established the positive standard.[5]

My appointment to the Staff in 1889 was timely from another standpoint, for Gibney, who had succeeded Knight as Surgeon-in-Chief, had made a radical departure from the established routine by improvising an operating room. It may be noted that the surgery of the period was purely corrective in its scope and that the great majority of the operations reported by Gibney were of the subcutaneous type. Yet this modest innovation, in the development of which my training and inclination qualified me to assist, was the propelling force in the transformation of a home for crippled children into a representative hospital.

In 1903 a ward for women was established, and in 1917 men were admitted to the Hospital Service. In 1889 there were but 190 admissions to the Hospital; in 1929 the number had risen to 4,113. In this year (1929) there were 3,522 operations. Of these, 1,875 were classed as orthopaedic and 1,647 were credited to the hernia department. Thus by the natural development of its resources, in which the indoor and outdoor departments supplemented one another in a reciprocal service, the Hospital had become the leading exponent of constructive surgery for both the ruptured and the crippled.

In the two examples of adaptive surgery that have been presented, operative intervention is an occasional and supplementary expedient. In a third illustration it is the positive and introductory feature. This is the operation of astragalectomy and backward displacement of the foot for paralytic calcaneus, which was then almost as much of a therapeutic derelict as the two instances cited.[5]

In a typical case, the patient limped about on the insecure support of a hypertrophied heel, to which the forefoot was a useless appendage. The astragalus was removed in order to reduce both the vertical and lateral deformity and to assure security by implanting the malleoli on the basic structure of the foot, thus changing a complex joint to a simple joint. The backward displacement reduced the adverse leverage and utilized weight-bearing on the contracted arch to restore symmetry. Finally and most important, the tarsus was brought beneath the anterior border of the tibia, thus providing the positive check to dorsal flexion essential to security in progression.

This readjustment of the statics and mechanics of the disabled member proved so effective in restoring relative stability that more than 2,000 of these operations for this and other forms of paralytic disability were performed during my term of service.

As a student of the range of operative intervention in a class of cases in which, as in this instance, the injury to function was irremediable, I had the advantage for many years of a continuous service in both the indoor and outdoor departments of the Hospital to supervise an operation from inception to conclusion, and thus, by comparison with the original condition, to estimate fairly from the patient's standpoint its functional utility.

Such comprehensive control is almost essential to the appraisement of the relative value of an operation, which in one instance may be designed to relieve the patient from artificial support and in another only to make such support more tolerable and effective.

Adaptive surgery has a wide range of availability. The three procedures cited to represent its principles illustrate, in order of presentation, the prime factors of artificial, anatomical, and operative mechanics correlated in the reconstructive treatment of three unrelated disabilities. Each of them has withstood the test of time or, specifically, the opposition proportionate to its divergence from the established practice, as best exemplified by the abduction treatment in which the divergence was of both method and standard. They may be accounted, therefore, as stable contributions to what has been termed "the transformation of orthopaedic surgery".

The ancient, ambiguous but irreplaceable term "orthopaedic", which for those who accepted its restrictions was an insuperable obstacle to progress, is now generally understood as indicating only a sphere of action. As such, it is especially concerned with impairment of bodily structure and function from any cause, and with prevention and cure, as well as with relief. This is a broad, ill-defined, expanding, and consequently only

partly charted therapeutic field, in which orthopaedic treatment, although it has no preferential jurisdiction, retains as a special attribute a "follow through". Thus a purposeful initiative is supplemented by equally purposeful after-care, which is often the determining factor in the result, if reckoned in terms of useful function.

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BONE-MARROW EMBOLISM FOLLOWING FRACTURE

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When fat embolism of the lungs and brain occurs, it most often follows fractures of the shafts of the long bones. In adults, the marrow of these bones consists largely of olein, which is a liquid at body temperature. Fat embolism occurs less frequently after fractures of the flat bones or fractures of the ends of the long bones; in these locations the marrow cavity is composed mainly of hemopoietic tissue. Although the historical, clinical, roentgenographic, and anatomical aspects of fat embolism are well known[3,4], and more than 600 cases have been recorded in the literature, only one case of associated bone-marrow embolism to the lungs has been reported[5]. Pulmonary embolism caused by marrow fragments has been described in eclampsia.[1] The occurrence of this process after skeletal trauma has been mentioned by MacCallum, without further comment. It seems probable that bone-marrow embolism, associated with fat embolism, occurs frequently after fractures. It would be necessary to examine the entire pulmonary tissue by microscopic sections in order to demonstrate the few fragments of marrow which have been liberated into the vascular system at the fracture site. The finding of such emboli in a few random sections of pulmonary tissue is purely accidental.

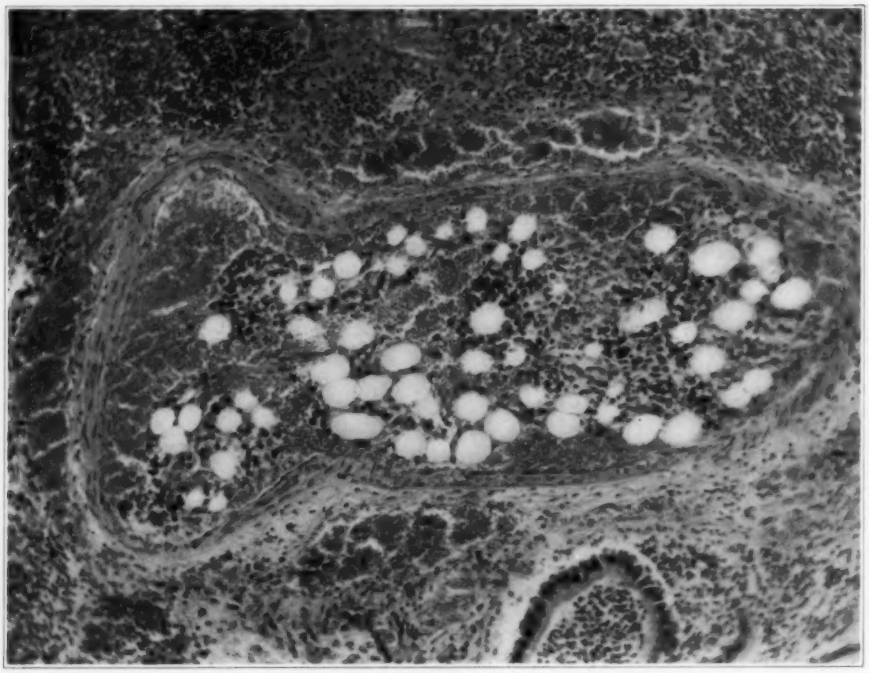

FIG. 1

Case 1. Hematoxylin and eosin stain (× 120).

CASE REPORTS

CASE 1. A white sailor, twenty-one years of age, entered the Hospital shortly after he had fallen from a door of a rapidly moving train. Upon admission, he was unconscious and his breathing was stertorous. There was profuse bleeding from the nose and mouth. Multiple lacerations of the right side of the scalp and an extensive laceration, extending into the lateral aspect of the right knee joint, were noted. Numerous superficial abrasions were present on the scalp, shoulders, elbows, and hands. There was an oblique fracture through the lower portion of the lateral condyle of the right femur. The patient's temperature was 103 degrees, the respiratory rate was 28, the pulse rate was 120, and the blood pressure was 115/60. During a seven-hour period, the patient had ten generalized convulsions, characterized by extension and stiffening of the extremities, flexion of the head to the right, and opisthotonos. The Babinski sign was positive bilaterally, and the knee jerks were increased but equal. His temperature gradually became elevated to 105 degrees, the respiratory rate increased to 50, and the pulse rate to 156. Death occurred thirty-nine hours after injury and thirty-four hours after the onset of convulsions.

At autopsy, the lungs were large, voluminous, tense, and firm. Both the pleural and the cut surfaces showed a distinct mosaic appearance, with alternating zones of marked congestion, hemorrhage, and grayish consolidation. A large amount of frothy, sanguineous fluid exuded from the cut surfaces. There was a mild subarachnoid hemorrhage over the cerebral hemispheres, most marked on the superior surface on the right side; similar hemorrhage was observed on the superior surface of the cerebellum. Multiple hemorrhages, one to four millimeters in diameter, were scattered throughout the cortex, the white matter, and the basal ganglia of the cerebral hemispheres; they were most numerous in the frontal lobes and on the right side.

Histological changes were limited to the lungs and to the brain. Staining with sudan IV showed the absence of lipid material in the lumina of the cardiac and renal blood vessels. The pulmonary arteries and veins, and the capillaries of the alveolar walls, were distended with blood. In one of the many pulmonary sections was a branch of the pulmonary artery, which measured approximately 370 by 950 micra. Its lumen was almost completely filled with a large fragment of well-defined bone marrow (Fig. 1). This consisted of numerous fat cells, erythropoietic cells, and myelopoietic cells, several megakaryocytes, and supporting connective-tissue cells. By serial sections, this segment of marrow could be followed in the lumen of the vessel for a distance of 70 micra. The marrow embolus had lodged at the bifurcation of the vessel, and extensions of it could be followed into the two branches. These branches measured 250 and 340 micra in diameter, and were almost completely filled with the embolic mass of marrow tissue.

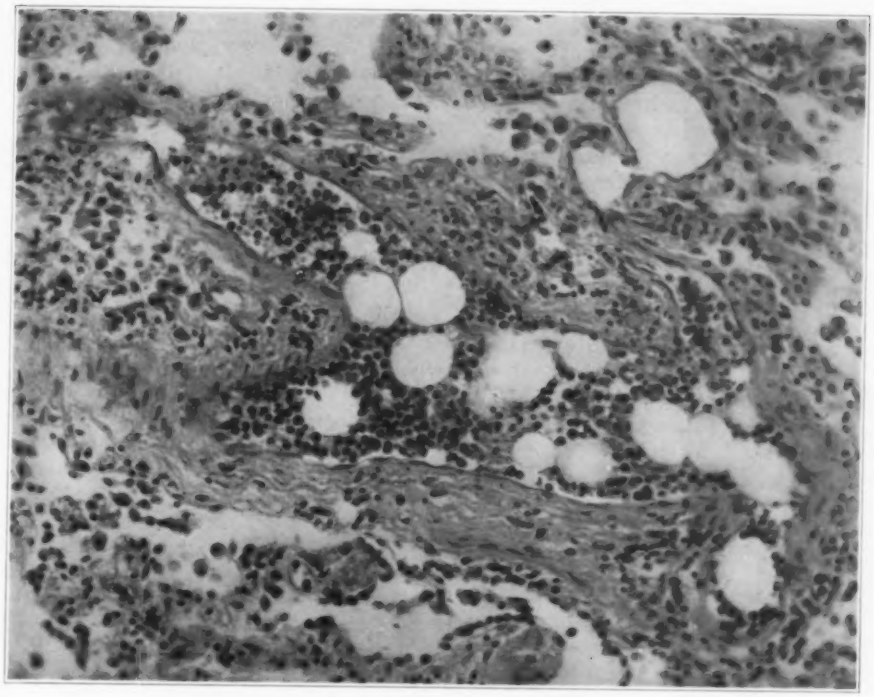

FIG. 2

Case 2. Hematoxylin and eosin stain (× 180).

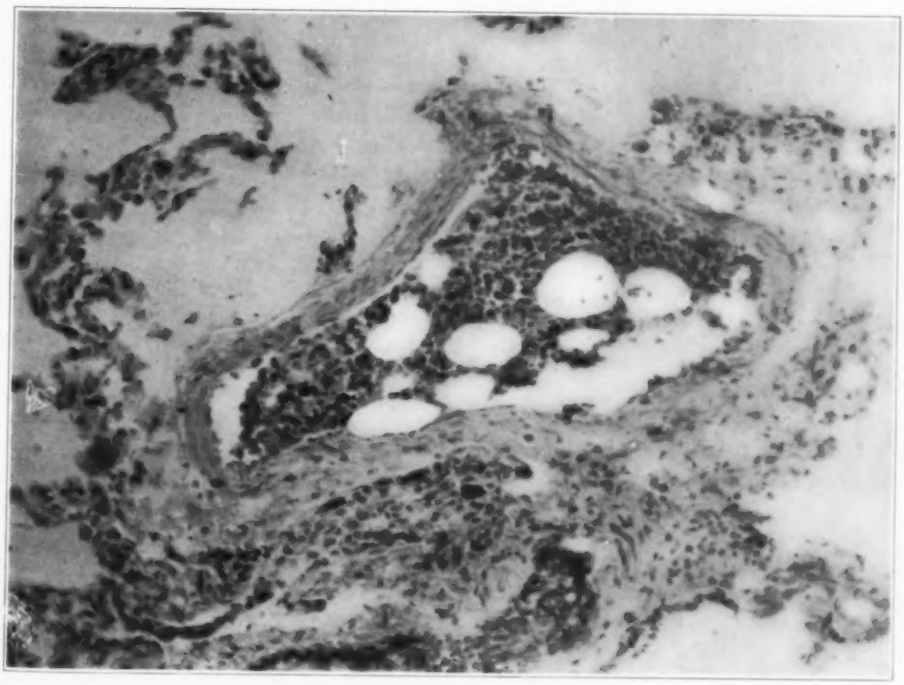

FIG. 3

Case 3. Hematoxylin and eosin stain (× 180).

Most of the alveoli and the bronchioles were filled with seropurulent exudate. Others contained red blood cells, serous fluid, fibrin, and macrophages containing blood pigment. Staining with sudan IV demonstrated globules of neutral fat in the lumina of many of the larger pulmonary vessels and in the capillaries of the alveolar walls. Smaller lipid globules also lay in the alveolar spaces. Some had been ingested by macrophages and by neutrophilic leukocytes.

Many small hemorrhages were present in the cerebral hemispheres, most often in a perivascular situation. Moderate amounts of blood were present in the subarachnoid space. Many of the small cerebral arteries were distended, but empty. No lipid material within them could be demonstrated by staining with sudan IV.

CASE 2. A white merchant seaman, forty-five years of age, was strangled while in an alcoholic state and was thrown 250 feet down a steep, rocky cliff, where he was found dead the following morning. At autopsy, there was anatomical evidence of strangulation and asphyxia. There were multiple fractures of the skull, sternum, left clavicle, mandible, right radius, ribs, and seventh thoracic vertebral body. Multiple lacerations and abrasions of the skin, cardiac contusion, and hepatic and renal lacerations were also noted. Inspection of the brain showed moderate subarachnoid hemorrhage, and numerous petechial hemorrhages were present throughout the white matter of the cerebral hemispheres. In addition to the subpleural asphyxial hemorrhages, both lungs were mildly congested and oedematous.

The capillaries of the alveolar walls were moderately distended with blood. Small amounts of serous fluid and numerous macrophages containing pigment were present in the alveolar spaces. Some of the alveolar spaces were emphysematous; others were atelectatic. Staining with sudan IV revealed only a few pulmonary vessels which contained lipid globules. In one of the many sections examined the lumen of one branch of the pulmonary artery, measuring about 240 by 640 micra, was almost completely occluded by a fragment of bone marrow (Fig. 2). This was composed of well-defined erythropoietic and myelopoietic elements, and a few fat cells. There were no megakaryocytes. The marrow embolus could not be demonstrated in serial sections. No lipid material was evident in the lumina of the renal or the cerebral vessels, when stained with sudan IV.

CASE 3. A white soldier, twenty-three years of age, collided with an automobile while he was riding a motorcycle. He was dead a few minutes later, upon arrival at the Hospital. At autopsy the following lesions were found: multiple comminuted fractures of the skull and the sternum; fractures of the left radius and ulna, the left femur, and the right tibia and fibula; contusions of the forehead, nose, lips, chest, and left shoulder; contusions of both lungs; lacerations of the left kidney; and subdural and subarachnoid hemorrhages.

The capillaries of the alveolar walls were mildly congested. Many alveoli were filled with red blood cells. Several sections of pulmonary tissue were made; one contained a single branch of a pulmonary artery, measuring about 215 by 400 micra, which contained a fragment of well-defined bone marrow (Fig. 3). This material almost filled the lumen and was composed of erythropoietic and myelopoietic elements, two megakaryocytes, and several fat cells. The embolus could not be demonstrated in serial sections. Although staining with sudan IV was not done on the cerebral, pulmonary, and renal tissues, there was no vacuolation of the vascular contents, which might suggest the presence of lipid globules.

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BILATERAL EXTRA-ARTICULAR ANKYLOSIS OF THE HIP JOINT

BY A. R. BUCHANAN, M.D., DENVER, COLORADO

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A cadaver of a white male, who was thirty-eight years of age at the time of death, was found, during the course of its dissection by two members * of the first-year class in anatomy, to have bilaterally immobile hip joints. Complete exposure of the hip regions revealed that the immobility was due to well-developed, completely extra-articular arches of bone, located anterior to the joints (Figs. 1-A and 1-B). On each side the bony arch extended from the region of the anterior inferior iliac spine to the anterior surface of the femur. Both hips were fixed in the position of moderate flexion.

Roentgenograms, showing the relation of the bony arches to the hip joints, are reproduced in Figures 2-A and 2-B. Grossly and roentgenographically, the arches had the appearance of true bone. Sections from one of them were ground and mounted on slides. Microscopic examination proved that they were actually bony structures, rather than mere depositions of calcium salts (Fig. 3).

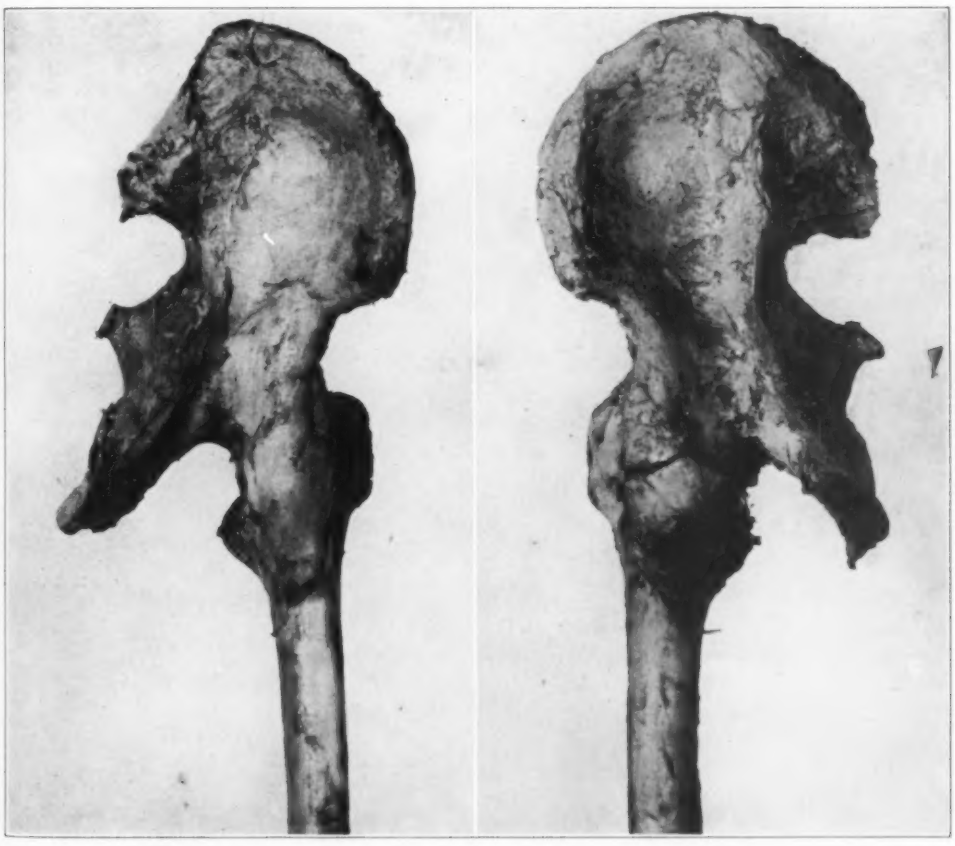

FIG. 1-A

Photograph of left innominate bone and femur, showing the bony connection between ilium and femur.

FIG. 1-B

Photograph of right innominate bone and femur. The bony process was fractured by forceful abduction of the thigh.

* Walter F. Anderson and Donn Richard Barber.

The tendons of the iliopsoas and pectineus were not involved in the osseous process on either side. There was, however, considerable atrophy of the iliacus and pectineus, which was to be expected since no movement of the femur in relation to the pelvis was possible.

The bony arch on the right side was fractured when the students attempted to abduct and flex the thighs to facilitate dissection of the perineum (Figs. 1-B and 2-B). Subsequent to this fracture, the head of the femur was freely movable within the acetabulum. Examination of the joint on the left side showed that it also was free of any intra-articular ankylosing process.

The iliofemoral ligaments (Y-shaped ligaments of Bigelow) could not be demonstrated, although the posterior and inferior portions of the joint capsules were present and were normal in appearance. The positions and relationships of the bony processes were such as to make it seem probable that they might have developed as ossifications of these ligaments. The cross sections taken from the arch on the left side proved to be much more densely ossified in their deeper strata than in their more superficial (anterior) strata.

According to the available history, this individual entered the Colorado School for Mental Defectives at the approximate age of eight years and remained there for twenty-two years. The remaining eight years of his life were spent in the Colorado State Hospital. He was the third of eight children and weighed eleven pounds at birth; the birth was recorded as prolonged.

An undated note, made during his long stay at the School for Mental Defectives, described his gait as "slow, uncertain, and shuffling". Upon admission to the State Hospital his gait was again described as "slow and shuffling", with poor coordination. The diagnosis on admission was "mental deficiency—idiot".

During the last seven years of his life he was bedfast, very deteriorated mentally, and indifferent to his surroundings. Occasional convulsions were recorded during the last two and one-half years.

The only abnormality recorded during the course of the dissection, other than the externally

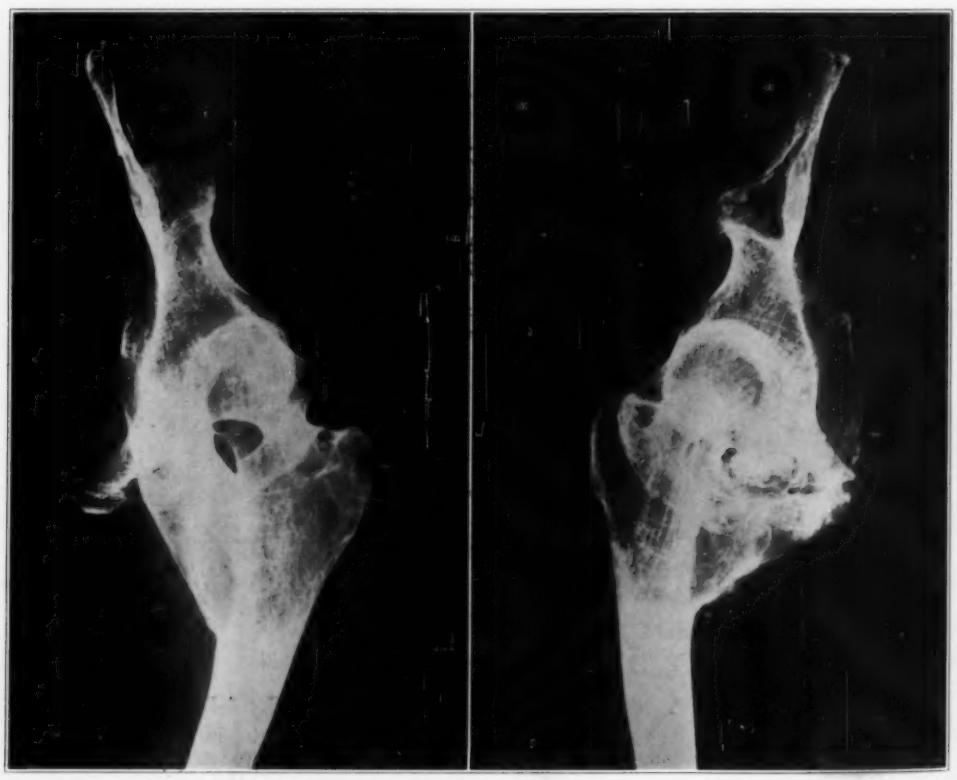

FIG. 2-A
Roentgenogram of left hip joint.

FIG. 2-B
Roentgenogram of right hip joint.

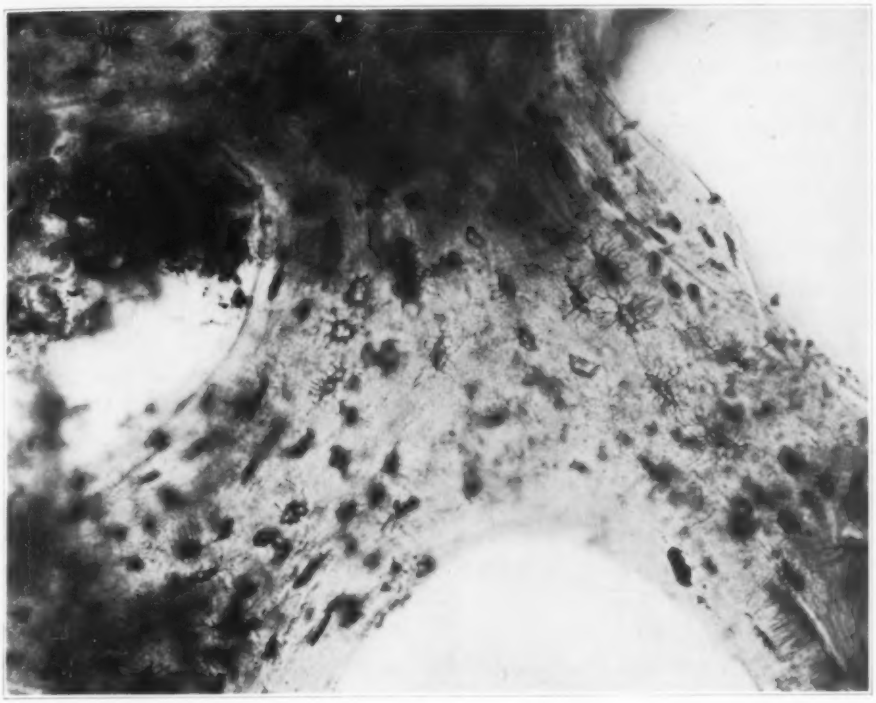

FIG. 3

Photomicrograph of a small area of a ground section from the bony process which was responsible for the extra-articular fixation of the right hip joint. Lacunae and canaliculi originally occupied by bone cells are clearly visible.

ankylosed hip joints, was a tremendously enlarged sigmoid colon. No other joints were similarly involved. The brain was not examined.

DISCUSSION

So far as could be determined, no report of a similar case of bilateral ossification of the iliofemoral ligaments has previously appeared in the literature. Kazakov and others have reported unilateral extra-articular ankylosis of the hip due to myositis ossificans, following some type of trauma.

Although the ossification that occurred in this case did not involve the connective tissue within the muscles—a finding which is supposed to be characteristic of the entity known as myositis ossificans—one is inclined to apply that name to it. In his discussion of myositis ossificans, von Pannewitz divided his ninety-four cases into three groups: those in which there was ossification of the joint ligaments and capsule following joint injuries (especially dislocation), those in which there was ossification of muscle as a result of a single trauma, and those in which ossification of muscle occurred after repeated slight traumata. In most of the cases described by von Pannewitz there was involvement of muscles. He did, however, refer briefly to a case in which there was ossification limited to the plantar aponeurosis, as a result of a crushing injury to the foot. The plantar aponeurosis is not considered to be a ligament, but its structure and function are similar to those of ligaments. Gruca stated that ossification of the joint capsule had been observed by a number of individuals who investigated myositis ossificans, but he failed to include specific bibliographical references to these investigators.

The various ideas as to the etiological factors in myositis ossificans have been discussed by Painter, Noble, and others. Bowers commented upon the frequency of the

condition in insane persons. Noble stated that most of the cases occur in males, during early adult life.

It is, of course, impossible to come to any definite conclusion as to the time of inception of the condition found in the cadaver described herein. The "slow, uncertain, and shuffling" gait noted at some time during his stay at the School for Mental Defectives was no doubt due, at least partially, to the ankylosis of the hip joints. There was no definite history of trauma that might have accounted for the condition.

There is a somewhat remote possibility that bilateral trauma, responsible for ossification of the iliofemoral ligaments, could have occurred at the time of birth. The prolonged labor may have been complicated by uterine inertia, which necessitated podalic version and extraction. Excessive traction exerted through the relatively undeveloped hip joints may have resulted in injury to those portions of the capsules which eventually thicken to form the iliofemoral ligaments. It is then necessary to assume that the subsequent growth of the pelvis and femora was accompanied by proportionate growth of the bony arches. That such growth could occur does not seem an unreasonable assumption, since there is a separate center of ossification for the anterior inferior iliac spine.

The history of convulsions might be considered significant in this case, if it had extended over a long period, but it does not seem likely that bony processes so well developed as to appear to have been associated with the normal ossification of the pelvis and femora could have been developed during the last two and one-half years of the subject's life. It might be suggested that the ligaments ossified during the prolonged period (seven years) during which he was bedfast and completely inactive, but this would preclude any connection between the bony formation and his manner of walking. Furthermore, all normal processes of ossification in the pelvis should have been complete at the time he became bedfast.

Whether an ossifying diathesis was associated with the mental derangement in this individual, as mentioned by Bowers, cannot be determined. It would seem that other sites of abnormal ossification would probably have been found, if the process had been the result of such a diathesis.

Spondylitis adolescens (Strümpell-Marie disease) was considered as a possible explanation for the ossification of the iliofemoral ligaments in this case. It was ruled out because of a lack of fixation in the sacro-iliac joints which, according to Blair, are usually the first to be attacked in this disease.

NOTE: The author appreciates the cooperation of F. H. Zimmerman, M.D., Superintendent of the Colorado State Hospital, who furnished the available history of this case. The bone sections were prepared by H. M. Kingery, Ph.D., and the illustrations by Glenn Mills; their help is gratefully acknowledged.

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A BILATERAL ANOMALY OF THE WRIST

Report of a Case

BY MAJOR R. D. BUTTERWORTH AND CAPTAIN W. E. DANER
Medical Corps, Army of the United States

An unusual type of congenital deformity of the wrists, unique in the experience of the authors, was observed. The deformity was bilateral, with fusion of all the carpal bones and of the second, third, fourth, and fifth carpometacarpal joints on the right; and fusion of the capitate and hamate bones on the left.

A perusal of available textbooks and periodicals revealed a case reported by White [1] of bilateral congenital fusion of the capitate and hamate. He states that such fusion is rare, as judged by the paucity of reported cases.

Fig. 1-A

Fig. 1-B

Fig. 1-A: Shows fusion of all carpal bones and of the second, third, fourth, and fifth carpometacarpal joints on the right. The capitate and hamate on the left are fused.

Fig. 1-B: Additional views of right wrist, showing fusion.

CASE REPORT

An infantryman, twenty-three years of age, entered the hospital with the complaint of pain in his right wrist. There was no history of recent trauma, but he had injured the same wrist one year before, while playing with a medicine ball. Several weeks of immobilization had resulted in complete relief. There was no history of infection of this or of any other joint.

Physical examination was essentially negative, except for about 10 degrees of limitation in flexion and extension of the right wrist, and complete fixation of the carpometacarpal joints, demonstrated by efforts at compression of the hand. There was no apparent weakness, deformity, or tenderness. A blood Kahn test was positive; all other laboratory studies were normal.

Roentgenograms of the right wrist, taken in several positions, showed complete intercarpal fusion, as well as fusion of the second, third, fourth, and fifth carpometacarpal joints. On the left, the capitate and hamate only were fused (Figs. 1-A and 1-B).

It was believed that the abnormalities were congenital, since there were neither history nor signs of infection; the trauma had been slight; fractures, old or new, could not be demonstrated; and this amount of fusion has not been seen even after severe compound fractures of the wrist. The changes were not characteristic of syphilis, although there was a positive history of this infection of four years' duration.

The function of the wrist was so good and the discomfort so slight that treatment was not instituted.

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FRACTURE-DISLOCATION OF THE MID-TARSAL AND CUBOIDEONAVICULAR JOINTS

Report of a Case

BY IRWIN A. JASLOW, M.D., SAYRE, PENNSYLVANIA

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An unusual type of fracture-dislocation of the foot—the result of a severe crushing injury—was seen recently. The dislocation, associated with multiple small fractures, was a medial displacement at the mid-tarsal joint (Chopart's joint) in which the navicular was displaced farther on the talus than was the cuboid on the calcaneus. Thus, there was a diastasis between the navicular and cuboid, and the dislocation was in the form of a T. By roentgenogram, the displacement at the horizontal arm of the T (the mid-tarsal joint) was readily seen (Figs. 1-A and 1-B), but the vertical arm between the navicular and cuboid was only demonstrated at operation. Key and Conwell [1] state that the mid-tarsal

Fig. 1-A

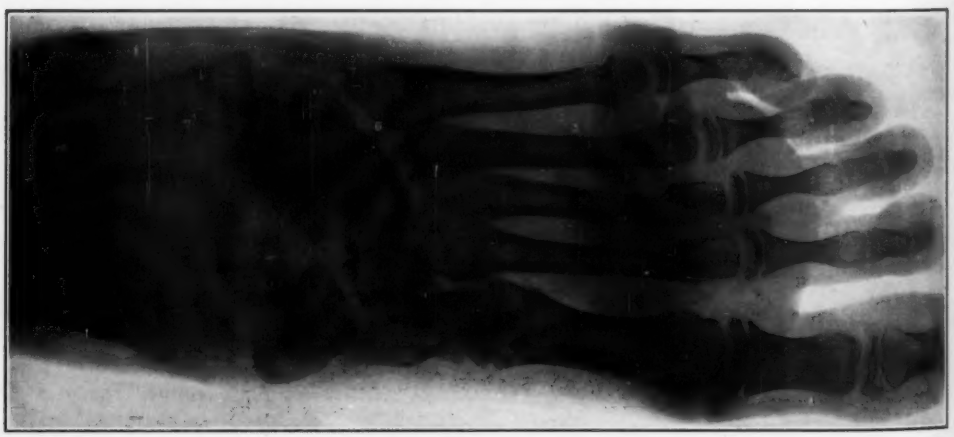

Fig. 1-B

Roentgenograms reveal the position of the dislocated bones on admission. The medial displacement of the navicular and cuboid is well demonstrated.

dislocation is "a rare lesion", and the presence of the diastasis in this case would seem to contribute to the rarity.

CASE REPORT

An eleven-year-old boy was seen in the Clinic on March 2, 1945 with a painfully swollen left foot. He stated that twelve days previously he had been riding a pony and that the animal fell and rolled on his left foot. Roentgenograms revealed a fracture-dislocation of the talonavicular and calcaneocuboid joints with possible fracture of the third cuneiform bone and incomplete fractures of the necks of the second and third metatarsals. Because of the time which had elapsed since the injury, open reduction was elected and the patient was operated upon the following morning.

The talonavicular joint was opened through a dorsomedial incision, one and one-half inches long, and the joint space was freed of organizing fibrous tissue by sharp dissection. Reduction was then attempted with the aid of a skid, but resistance was encountered and it was felt that there must be a block at the calcaneocuboid joint. Accordingly, the calcaneocuboid joint was exposed through a one-inch lateral incision and the fibrous tissue was removed. It became evident that there must be a diastasis between the navicular and cuboid bones. The dorsal cortices of both the navicular and cuboid were fractured and, when a crocheted cotton ligature was pulled up through awl holes between these bones, it tore through the osteoporotic bone. A stainless-steel screw was inserted into the medial aspect of the navicular, through a large drill hole, and tapped into the cuboid; the pull-up action of the screw was utilized to reduce the diastasis. Then the dislocation at Chopart's joint was reduced easily, and position could be maintained with minimum pressure.

FIG. 2-A

FIG. 2-B

Showing the position four months after operation. The bones are in relatively normal position.

A skin-tight cast was applied from the toes to the tibial tubercle. Seventeen days later a walking iron was added to the cast, and the patient was allowed to bear weight. Four weeks later, when the cast was removed, the wound had healed. Four months after operation the patient walked with a normal gait and the foot was asymptomatic (Figs. 2-A and 2-B). Approximately 25 per cent. of the pronation-supination of the foot was lost. The fractured necks of the second and third metatarsals healed with minimum angulation, which is not clinically significant.

The immobilization of joints by rigid internal fixation is usually not advocated for the treatment of fractures or dislocations. In this case, however, it was the only means at hand for maintenance of the reduction. The case is reported because of the good result obtained and the minor degree of limitation of motion.

1. Key, J. A., and Conwell, H. E.: The Management of Fractures, Dislocations, and Sprains, Ed. 3. St. Louis, The C. V. Mosby Co., 1942.

AVULSION OF THE ISCHIAL TUBEROSITY

Report of a Case

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The paucity of cases reported in the literature would indicate that avulsion of the ischial tuberosity occurs rarely. In 1937 Cohen reported a case, and he reviewed three cases which had previously been recorded. McMaster has recently reported an additional case.

CASE REPORT

A white male, twenty-four years of age, was seen in the Orthopaedic Clinic of the Station Hospital; he complained of pain in his left buttock of eight years' duration. He gave the following history: While playing football at the age of sixteen, he stumbled to the ground and a fellow player fell on top of him. He did not remember the exact nature of the fall. A sudden, severe pain in the left buttock first developed at that time, and his left lower extremity became very painful on weight-bearing. He was examined by a physician, who recommended a period of rest in bed. No roentgenograms were made. The patient was confined to bed for from six to seven weeks. He limped for "a number of months" after the injury; with every step there was associated deep-seated pain in his left buttock. Gradually, this pain on weight-bearing subsided. He gave no history of acute aggravation of symptoms by any subsequent trauma, either direct or indirect.

FIG. 1

Anteroposterior view of the pelvis, showing avulsion of an enlarged crescentic secondary epiphysis of the left ischial tuberosity.

When examined in the Orthopaedic Clinic, the patient complained that stooping evoked a moderate amount of pain at the site of his previous injury; that, if he sat on his left side for any length of time, an ache of progressive intensity developed; and that weight-bearing on his left lower extremity was painful, when he was physically burdened.

Physical examination revealed a well-developed white male, twenty-four years of age. His posture and gait were normal. Inspection of the buttocks revealed no asymmetry. Although there was no tenderness on palpation over the left ischial tuberosity, heavy percussion produced some deep-seated pain. The epiphysis was rigidly fixed and the range of motion of the left hip joint was normal. Forced flexion of the thigh on the abdomen, however, caused a moderate degree of "pulling" or "tearing" pain in the left buttock. Forward bending evoked the same complaint. When compared with the right lower extremity, the left mid-thigh was atrophied one inch and the left calf was atrophied one-half inch. Both lower extremities were of equal length.

Roentgenographic examination revealed a large crescentic secondary epiphysis of the left ischial tuberosity, ununited to the body of the ischium. The apposing surfaces were irregular in contour. A small area of calcification above the superior border of the fragment was interpreted as ossification of a previously existing hematoma.

This patient was given diathermy, but remained ambulatory. He was assigned to limited duty, and was advised to refrain from strenuous activity. No significant change was observed in his condition during the two months in which observation was possible.

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ISOLATED FRACTURE OF THE PISIFORM BONE

Report of a Case

BY MAJOR VIRGIL MCCARTY AND MAJOR HARRY FARBER

Medical Corps, Army of the United States

From the Orthopaedic Section, Station Hospital, Camp Howze, Texas

Fracture of the pisiform bone is a rarity in medicine, if one may judge from the very few cases of this condition which have been reported. The first known case occurred in 1847. Jaeger collected eleven cases in the literature, and in addition reported a case which he had observed. Two cases were reported by Jean and one by Briggs, making a total of approximately sixteen cases.

The exact mechanism involved in the production of fracture of the pisiform bone has never been defined clearly. Exhaustive studies by Jean and Solcard, however, indicate that the most probable mechanism is that of hyperextension of the wrist, with the forearm in pronation and adduction. Jean and Solcard observed an accidental fracture which occurred during hyperextension and adduction. It is evident that both of these mechanisms, that is, adduction and pronation, are strikingly similar.

Doubtless there are many cases of pisiform fracture which have not been reported and perhaps a great many others which have gone undetected; but, due to the rarity of the condition, the following case is presented.

CASE REPORT

A white soldier, twenty-three years of age, reported at the Orthopaedic Clinic on May 23, 1944. He stated that three days previously, while he was running to the mess hall, he stumbled and fell on his outstretched left hand, striking it against a stone on the ground. Examination revealed abrasions of the left thumb and the left thenar aspect of the thumb. There was point tenderness over the volar aspect of the left wrist, overlying the pisiform bone. No crepitus was noted. Roentgenograms of the left wrist revealed a fracture of the pisiform bone, without displacement. A roentgenogram of the right wrist, taken for comparison and to rule out pisiform secundarium (accessory pisiform) was found negative.

A lightly padded circular plaster cast was applied to the left forearm and hand, with the wrist in the position of slight palmar flexion and ulnar deviation. The metacarpophalangeal joints were not immobilized. This patient was treated in the Out-Patient Clinic and returned to light duty. It was necessary to reinforce the cast on June 15. On June 22, the cast was removed and a roentgenogram was reported as follows: "Re-check of the left wrist fails to visualize the fracture line of the pisiform, apparently due to healing". Immobilization was discontinued at this time. The patient was observed one week later, and at this time he apparently had full function and no residual disability.

Fig. 1

Fracture of pisiform bone of left wrist.

The authors believe that roentgenographic studies should be made of every wrist injury, even though it may appear extremely slight. Three views are essential. Delayed treatment or failure to recognize such fractures may result in prolonged treatment and unnecessary disability. The treatment recommended consists of immobilization by plaster cast or molded splint, with the wrist in a position of mild palmar flexion and ulnar deviation.

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SUBMENISCAL FOREIGN BODIES IN THE KNEE

Report of Two Cases

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The diagnosis, localization, and surgical removal of loose bodies within the knee present interesting and difficult problems. It is not sufficiently well recognized that foreign bodies, both endogenous and exogenous in origin, may be located underneath the menisci.

Geist has reported two cases in which chondro-osseous bodies were removed from beneath the anterior horn of the lateral meniscus. Bizarro described a case in which a fragment of glass was found beneath the posterior horn of the lateral meniscus. The author has published his experience with a case in which fragments of a sea shell were removed from the submeniscal compartment of the posterior horn of the medial meniscus.

The first case to be presented revealed a fragment of glass underneath the anterior horn of the lateral meniscus. In the second case, a chondro-osseous body was discovered beneath the anterior horn of the medial meniscus.

CASE REPORTS

Case 1. E. A., a white woman, seventy-nine years old, appeared in the Emergency Room of the New Haven Hospital on November 11, 1944, with the complaint of a cut on the left knee. Shortly before admission, the patient had tripped on a curbstone while carrying a glass jar of ground coffee. She had fallen upon the left knee.

Examination revealed a ragged, transverse laceration, eight centimeters in length, on the anterolateral aspect of the left knee. The interior of the knee joint was easily seen through the wound. Coffee grounds and dirt were embedded in the laceration, but no glass was seen. It was noted that the patella was higher than normal. No active extension of the knee was possible. There was no evidence that the peroneal nerve had been injured. Roentgenograms (Fig. 1) showed a radiopaque object, presumably glass, embedded deeply within the substance of the proximal end of the tibia.

The diagnosis, therefore, was compound wound of the knee joint, compound fracture of the tibia caused by a fragment of glass, and laceration of the patellar ligament. After the usual prophylactic dose of mixed tetanus and gas-bacillus antitoxin had been given, the patient was brought to the operating room.

The wound was cleansed and débrided. Numerous fragments of glass were removed from the surrounding soft tissue, as was also the large fragment which was buried deeply in the tibia. Careful inspection of the wound led to the conclusion that all the glass had been found. Experience with the previous case, mentioned above, led the operator to suspect that some foreign body might be concealed beneath the meniscus. Therefore, the submeniscal compartment of the anterior horn of the lateral meniscus was explored. A piece of glass about two centimeters in length was uncovered and removed. The patellar ligament was repaired and the wound was closed without drains, following a copious irrigation of the knee joint and wound with saline. A cast was applied. The postoperative course was uneventful, and the wound healed by first intention. Eight weeks later the cast was removed and physiotherapy was started. The patient was last seen on August 7, 1945. Extension and flexion were complete. There was no pain or limp. Muscle strength and stability of the joint were normal.

Comment: In this case, a large exogenous foreign object was completely concealed by a meniscus. If the operator had not been conscious of the possibility that the submeniscal compartment can contain and conceal foreign objects, contaminated material would most certainly have been left in the knee, and the result might have been much different.

Case 2. M. G., a fifteen-year-old white boy, entered the Clinic with the complaints of pain in the right knee and a swelling on the medial aspect of the right knee joint.

About two and one-half years previously, the patient had noted a small "growth" on the anteromedial aspect of the right knee in the region of the proximal end of the tibia. The localized swelling had increased in size, until six months before his present admission to the Clinic. There had been no pain in the knee during the first two years after the appearance of the tumor. During the next six months, an aching pain had developed, which was unrelieved by rest and was unaffected by activity. During the same period, there occurred intermittent attacks of severe knife-like pain, which lasted for from one to two minutes. These attacks increased in severity and frequency until, at the time of admission, several exacerbations were being experienced each day.

Fig. 1

Case 1. Dense foreign body may be seen in the region of the tibial tuberosity. This body is not the one found beneath the anterior horn of the lateral meniscus at operation. The lateral view added nothing of significance.

Fig. 2

Case 2. Note the triangular-shaped bony protuberance at the anterior joint line. Just above the outgrowth is a small detached chondro-osseous body, which was found beneath the anterior horn of the medial meniscus at operation. The anteroposterior view added nothing of significance.

The past history and family history were non-contributory.

Examination revealed a bony-hard tumor mass, four by four centimeters in size, on the medial aspect of the proximal end of the right tibia, just below the joint line. Both active and passive motions of the knee were complete, but they were painful. Roentgenograms (Fig. 2) revealed a bony outgrowth on the anteromedial aspect of the proximal end of the tibia. The superior surface of the outgrowth was level with the joint line. Situated above the exostosis was an irregular calcific shadow, probably representing a chondro-osseous joint mouse. The patient was admitted for arthrotomy, with the diagnosis of osteochondroma of the right tibia and joint mouse of the right knee.

At operation, the knee joint was opened in the region of the anterior horn of the medial meniscus. Lying between the inferior aspect of the meniscus and the superior aspect of the tumor, the loose chondro-osseous body was found. The tumor and the loose body were removed. The meniscus was left intact and the wound was closed in layers. An uneventful postoperative course ensued. All pain had completely disappeared. The patient was last seen three months after operation, and at that time the range of motion of the knee was complete and painless. The muscle strength and stability were normal. The patient engaged freely in strenuous sports and had been entirely asymptomatic.

Comment: The etiology of the development of the endogenous submeniscal foreign body in this case is not entirely clear. The outgrowth on the tibia guided the operator directly to the loose body. It is conceivable, however, that, if the tumor had not been present, a search for the loose body would have been made in the anteromedial compartment of the knee rather than in the submeniscal compartment. Under such circumstances, the object could not have been found. So far as the author is aware, this represents the first reported case of a foreign body being discovered beneath the *anterior horn of the medial meniscus*. This case, together with the one previously reported by the author and with the cases of Geist and of Bizarro, establishes the fact that objects may be concealed under the anterior or the posterior horn of either the lateral or the medial meniscus.

The purpose of this report is to call the attention of surgeons more emphatically to the presence of the submeniscal compartments of the knee, and to add to the literature the fifth and sixth cases in which a foreign body was encountered in such an obscure location.

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SPLINT FOR THE TREATMENT OF MALLET FINGER

BY HOWARD J. SCHAUBEL, M.D.,* AND ERNEST W. SMITH, B.S., DURHAM, NORTH CAROLINA

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The purpose of this paper is to describe a splint for the correction of avulsion of the extensor tendon of a finger from its insertion into the base of the distal phalanx.

Mallet finger usually occurs as a result of forced flexion of the distal interphalangeal joint while the extensor tendon is contracted, but it may follow a sharp blow directly over the insertion of the tendon. The injury is sustained frequently by individuals engaged in sports in which a hard ball is caught.

If the injury is not treated adequately by proper reduction and fixation, the ability actively to extend the distal interphalangeal joint is lost, and a flexion deformity develops, with characteristic baseball finger. Watson-Jones points out that the proximal interphalangeal joint becomes hyperextended, due to the uninhibited pull of the extensor tendon slips to the proximal portion of the middle phalanx, and that this complication may prove more incapacitating than the deformity at the distal joint.

The principle of treatment of mallet finger is to hyperextend the distal interphalangeal joint and to hold the finger in this position until the fracture has healed. Many splints have been devised to immobilize the avulsion fracture, as described by Lewin, Forrester and McLean, and Rider. Plaster casts have been used, but present the disadvantages that the plaster may become soft, the casts are usually bulky, they are difficult to apply properly, and they soil easily.

Recently, the junior author suffered a sprain-fracture of the distal phalanx of the right index finger. Because of hospital duties, it was necessary for him to have a splint which could be adjusted easily and which would not be damaged greatly by moisture. The splint which was devised is made as follows:

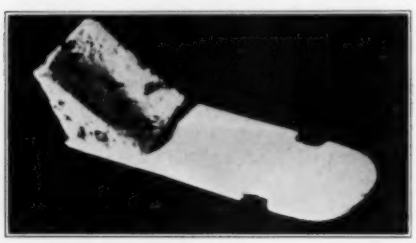

FIG. 1

Composite picture of parts of splint.

A tongue-blade is cut to the length of the injured finger, and two notches, one-quarter inch wide and one-eighth inch deep, are cut about half an inch from the curved end. A right-angle wedge, the width of the tongue-blade, with one-inch sides and a hypotenuse of approximately one and one-half inches, is cut from a large cork. A shallow groove, suitable to cup the distal phalanx, is cut in the hypotenuse of the wedge. The cork is then placed on the tongue-blade, as illustrated in Figure 1. Fixation of the cork

FIG. 2

Splint applied, with initial layer of adhesive strapping.

FIG. 3

Splint maintained with complete adhesive dressing.

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to the blade is maintained with glue and adhesive strapping. The distal phalanx of the injured finger is placed on the cupped wedge; the remaining phalanges rest on the flat, adhesive-covered tongue-blade. A thin layer of felt is placed over the dorsal surface of the distal interphalangeal area and the finger is fixed with half-inch adhesive strapping, with the distal joint in hyperextension (Fig. 2). One strip of the adhesive strapping is then cut with two butterfly slots. When the strapping is passed over the dorsum of the finger, the butterfly notches are fitted into the notches which had previously been cut on either side of the tongue-blade, to prevent slipping of the splint on the finger. The splint is further secured by running adhesive strapping beyond the most proximal part of the tongue-blade to the interphalangeal web, as indicated in Figure 3. Hyperextension of the distal joint is thus controlled and maintained.

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AN IMPROVED PEDAL FOR ELECTRICAL APPARATUS USED IN SURGERY

BY COLONEL PHILIP LEWIN

Medical Corps, Army of the United States

From the Mayo General Hospital, Galesburg, Illinois

Most bone surgeons who use the electrically driven saw, or other electrical apparatus, have had difficulty at times with the ordinary foot pedal. The cage, or pedal house, shown in Figure 1, was devised in order to avoid tipping, slipping, or moving of the pedal.

When the surgeon wears foot covers to protect his shoes, or wears muslin leggings, it is imperative that he be sure-footed. The presence of the cage minimizes the danger of accidentally stepping on the pedal, and eliminates uncertainty in locating the apparatus. It is of value in the use of the electrical saw and other apparatus, such as the Bovie electrocoagulator. It should have a wood or lead base, to avoid moving around too easily.

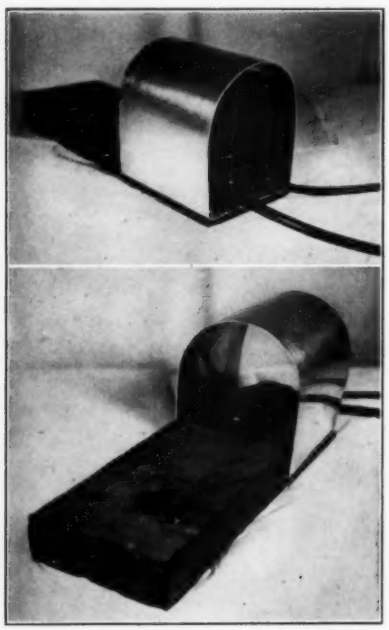

FIG. 1

Aluminum housing for electrical apparatus.

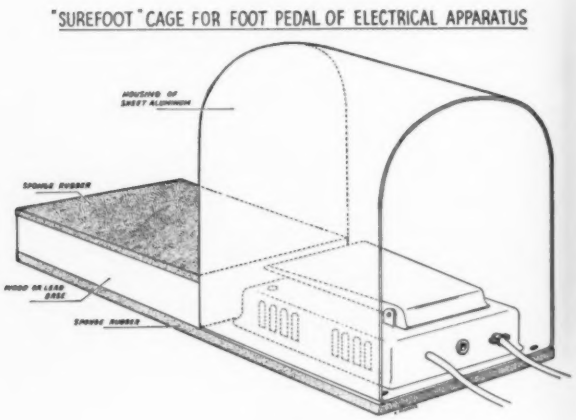
"SUREFOOT" CAGE FOR FOOT PEDAL OF ELECTRICAL APPARATUS
HOUSING OF SHEET ALUMINUM
SPONGE RUBBER
WOOD OR LEAD BASE
SPONGE RUBBER

FIG. 2

Sketch showing construction of apparatus.

The cage (Fig. 2) was constructed by Staff Sergeant Harry Burger, in charge of the Orthopaedic Shop of Mayo General Hospital, who describes it as follows:

"The housing for the safety switch is made from sheet aluminum. It is five inches wide and six inches high, and is formed from one piece of aluminum, five and one-half inches wide and nineteen and one-half inches long.

"The foot platform is made of wood, covered on the top and bottom surfaces with a quarter-inch sheet of sponge rubber; the bottom piece covers the lower surface of the entire assembly.

"The aluminum housing is riveted to the base plate of the switch, which may be easily removed and later screwed back into place.

"The connecting strip of metal joins the wood platform to the housing assembly. The piece is three thirty-seconds of an inch by fourteen and one-half inches in size, and is screwed to the center of the undersurface of the wood piece and riveted to the base plate of the switch."

SPLINT TO CORRECT DEFORMITY RESULTING FROM INJURY TO ULNAR NERVE

BY MAJOR ARTHUR M. PRUCE

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"Typical claw hand" is the textbook description for the deformity which frequently results from injury to the ulnar nerve. Due to muscle imbalance, the ring finger and the little finger are hyperextended at the metacarpophalangeal joints and are flexed at the interphalangeal joints. In addition, the little finger is abducted. Should the extensor muscles be permitted to shorten and the peri-articular tissues to become fibrosed, the resulting contracture will respond, if at all, only to prolonged and intensive treatment. In addition, the danger of joint subluxation and exaggeration of the deformity is constantly present.

This deformity can be prevented by early splinting, combined with guarded passive motion, which should be repeated several times daily. To offset the shortening of the extensor muscles and the bowstringing of the paralyzed intrinsic muscles, especially the lumbricales, the fourth and fifth fingers must be maintained in flexion at the metacarpophalangeal joints. The little finger must be adducted to prevent an abduction deformity, which leaves an interspace between the fourth and fifth fingers due to pull of the extensor digiti quinti proprius. This annoying deformity causes the little finger to catch on such things as pockets.

FIG. 1

Palmar view of splint in position.

FIG. 2

Wrist band and finger cuff of splint.

A simple splint, consisting of a soft leather cuff, encircles the proximal phalanges of the ring finger and the little finger and is attached to a wristlet by a rubber band, with the line of pull toward the navicular. Splinted in this manner, the metacarpophalangeal joints are flexed to approximately 90 degrees and the little finger is supported in adduction. Shortening of the extensors is prevented, paralyzed intrinsic muscles cannot be overstretched, and active exercise is possible from a physiological position. The splint should be worn until recovery is complete, or until hope of recovery is abandoned.

The splint is of no value in an established claw deformity with secondary contractures of the joints, and it is useless in those cases in which the transverse metacarpal arch of the involved digits has been broken by excessive manipulation. Follow-up studies on the splinted hands have been difficult to carry out, but the results that have been obtained thus far justify this type of splint.

INFECTION OF THE KNEE JOINT BY *CLOSTRIDIUM WELCHII*

Report of a Case

BY CAPTAIN WOODROW W. LOVELL

Medical Corps, Army of the United States

The following case is presented because of its interest and rarity.

A private in the Infantry, eighteen years of age, was wounded by a shell fragment on February 19, 1945, while in Germany. The penetrating wound at the point of entrance on the medial aspect of the right knee was débrided and the shell fragment, which was embedded in the medial condyle of the femur, was removed at an evacuation hospital shortly after the injury. After 40,000 units of penicillin had been instilled into the joint space, the synovial membrane of the knee joint was closed. The skin and the deep fascia were left open, the wound was packed with vaseline gauze, and a long cylindrical plaster cast was applied. Forty thousand units of penicillin was given intramuscularly every four hours for seventy-two hours.

Seven days later, the patient was evacuated to a general hospital in England. He appeared to be perfectly comfortable, and his temperature, pulse, and respiration were normal.

Three days after the patient had been admitted to the hospital, his cast was removed and the right knee was found to be moderately swollen. Thirty-five cubic centimeters of blood-tinged fluid was aspirated from the knee; one per cent. procaine infiltration anaesthesia was used. The wound on the medial aspect of the knee was dressed and a cast was applied. Two days later the patient complained of severe headache, nausea, and slight pain in the right knee. His temperature was 103 degrees, the pulse rate was 130 per minute, and the respiratory rate was 22 per minute. His cheeks were flushed and he appeared to be in a toxic condition. A general physical examination was entirely negative, except for a soft apical systolic murmur. The white-blood-cell count was 33,000, with 88 per cent. polymorphonuclear leukocytes.

The patient had not improved by the following day, and the pain in the right knee had increased in severity. A window was cut in the cast, and the knee was found to be swollen, tender, and hot. A second aspiration yielded sixty cubic centimeters of pus. Fifty thousand units of penicillin was instilled into the knee joint, and 30,000 units was given intramuscularly every three hours. The pathologist reported that a smear made from the specimen which had been aspirated from the knee showed large gram-positive bacilli, with apparent encapsulation. The culture was reported on the following day to contain a pure growth of *Clostridium welchii*. It was pathogenic to the mouse.

By parapatellar incisions, the knee joint was then opened on its medial and lateral aspects. The synovia was thickened, and seventy-five cubic centimeters of the same type of pus was evacuated from the joint. Fifty thousand units of penicillin was placed in the joint space and the joint was left open. The knee was immobilized in a posterior splint. The pus which had been removed from the knee at the time of operation was also reported, after culture, to contain *Clostridium welchii*.

Therapy included the intramuscular injections of penicillin and the instillation of 40,000 units of penicillin into the joint daily. Sulfadiazine, in a dosage of one gram every four hours, was administered orally, and 20,000 units of antitoxin for gas gangrene was given intramuscularly every four hours. The sulfadiazine level was maintained at eight milligrams per 100 cubic centimeters. Transfusions of whole blood were given as supportive therapy.

Although the patient's temperature continued to be elevated for several days, his general condition appeared to be much improved and there was little pain in the right knee. He was instructed to do quadriceps-setting exercises during part of each hour. Drainage from the knee ceased after two and one-half weeks, and the operative skin incisions were closed secondarily. Physical therapy and active knee motion were begun one week later.

Roentgenograms of the right knee showed minimum destruction of the articular cartilage. The range of motion at the time of evacuation to the Zone of Interior was from 180 to 160 degrees.

Education Section

PROGRESS REPORT OF THE JOINT COMMITTEE ON POSTGRADUATE TRAINING IN ORTHOPAEDIC SURGERY *

BY RALPH K. GHORMLEY, M.D., ROCHESTER, MINNESOTA

In his Chairman's Address before the Section on Orthopaedic Surgery of the American Medical Association in 1944, Dr. Guy Caldwell sounded the challenge to orthopaedic surgery, to be met in furnishing training to those men coming out of the Armed Forces who desired to complete their qualifications for the examinations of The American Board of Orthopaedic Surgery.

Dr. Caldwell estimated that approximately 900 medical officers were being drawn into contact with the specialty of orthopaedic surgery, and he predicted that more than half of these men would complete their training after the War. In the same address, Dr. Caldwell predicted that the number of men certified in orthopaedic surgery within the next five or ten years would be doubled or perhaps trebled, until it reached 2,000 to 2,500 men in the United States.

In the fall of 1944, after consultation with members of the Committee on Postgraduate Training in Orthopaedic Surgery of The American Academy of Orthopaedic Surgeons, the officers of The Academy of Orthopaedic Surgeons, and the officers of The American Orthopaedic Association decided to form a joint committee representing these two bodies, whose duty it would be to develop plans to meet the obvious challenge.

The list of available services for training orthopaedic surgeons, of the Council on Medical Education and Hospitals of the American Medical Association, showed eighty-four services so approved. Of them six were approved for three years of training, thirty-eight were approved for two years of training, and forty were approved for one year of training. These services offered facilities for 223 men in resident training. It was obvious to the Joint Committee that the list did not include all hospitals and institutions in this country where facilities for training orthopaedic surgeons should be available.

For this reason the Joint Committee decided to carry on a survey of its own to determine as nearly as possible where the facilities and personnel existed by which the number of residencies accredited for this training could be enlarged. The country was divided into a number of districts and the Committee asked certain orthopaedic surgeons to report on the facilities in their districts. After completion of the survey, the Committee met and reviewed the findings. Three facts were obvious: (1) A number of residencies in institutions, while having been depleted by the Orders of Procurement and Assignment, were functioning smoothly and could be expanded readily; (2) the staffs in a number of services which formerly had been well organized for teaching had been so depleted that training of residents had had to be abandoned and; (3) a number of institutions had the facilities and personnel, as well as the work, to make a creditable teaching service, but were not organized and not accredited.

By letters, personal visits, and conversations, the staffs of all hospitals in which the services seemed to the Joint Committee suitable for training orthopaedic surgeons have been urged to organize a teaching program and, if they had not already done so, to seek approval of the Council on Medical Education and Hospitals of the American Medical Association and of the Committee on Hospitals of The American Board of Orthopaedic Surgery.

Besides Dr. Caldwell's prediction of the number of men seeking additional training, the results of the pilot questionnaire sent by Lieutenant Colonel Lueth to the medical officers in the services were watched carefully. The earlier report from Lieutenant Colonel Lueth's office indicated that 297 additional residencies would be needed, if the officers were discharged at once. However, if these officers were dismissed over a period of two years, 127 additional residencies would be required. In his final report, Lieutenant Colonel Lueth [3] noted that 611 men wanted training in orthopaedic surgery. Of these, 487 desired long courses, and it was stated that 432 also wished to become recognized specialists.

In a later article [2] on postwar planning, an estimate of the probable required expansion of present teaching facilities was given. A tabulation indicates that the estimated additional postwar residencies required in orthopaedic surgery, if demobilization occurred at once, would be 444. The estimated additional residencies required, if demobilization extended over a period of time, was 201. It was found that 521 medical officers desired future certification by The American Board of Orthopaedic Surgery.

With these statistics in mind, the Joint Committee on Postgraduate Training in Orthopaedic Surgery has been doing everything possible to improve and extend the facilities to meet the demand. There are now approximately 400 residencies in orthopaedic surgery in the United States, which have been ap-

* Read before the meeting of The American Academy of Orthopaedic Surgeons, Chicago, January 22, 1946.

proved formally or provisionally by the Council on Medical Education and Hospitals and by The American Board of Orthopaedic Surgery. Several others are in the process of organization and should be functioning within a few weeks. Much effort has been put forth by many individuals and hospital services as well as medical schools to build up their resident-training program in such a manner as to retain their approved status and to have something definite to offer the returning veterans. The Committee cannot express too much appreciation of the tireless efforts of its colleagues over the country, who have helped so much to broaden the program of training.

The Joint Committee had hoped from its earliest meeting to be able to set up a Registry through which all applications could be filed, and thus to be able to advise the applicants of what supplemental training they would need to complete the requirements of the Board, and to inform them as to the services that would fill their needs. Due to inability to find adequate personnel to staff such a Registry, its formation has been delayed. However, within a short time a Registry will be set up and running. Dr. A. R. Shands, Jr. will be in charge and will carry on this work for the next few months at least. It is hoped that this will help to expedite the placement of those who are still seeking resident training.

In planning programs of training in orthopaedic surgery, it has been pointed out that the training must cover three phases: orthopaedic surgery for children, orthopaedic surgery for adults, and the surgery of trauma to the extremities and spinal column. In addition to these, all complete training programs should provide facilities for a review of basic medical sciences. The importance of this review is recognized in all surgical specialties. Training should include also information concerning developments in other branches of medicine and surgery. The importance of sound knowledge of anatomy and surgical pathology has long been recognized; opportunities for review and study of these subjects should be made available to all in resident training.

In order to clarify its attitude and to furnish a minimal standard, the Board has drawn up plans for basic science training. [The portion of the Report covering these plans was published in the January issue of *The Journal* (**28**: 189–190, 1946).]

In many instances training in these various phases must be divided among several institutions. Such affiliations have been encouraged by this Committee. Some excellent training programs have been developed in this way. We believe the future training of orthopaedic surgeons will be carried on largely by means of such affiliations. Thirty-eight institutions now are organized for three years of training, while in 1944 only six existed. Others will be organized. At present, approximately 190 residencies are available for three-year training programs.

It should be stated clearly and emphasized that this Committee does not mean to imply that training must be divided arbitrarily along the lines indicated, but it must cover all of the recommended phases, whether they are completed separately or concurrently.

Some of the difficulties in setting up such programs in wartime have already been mentioned. One that has been called to our attention frequently is that in the past few years many services have had the smallest number of hospital patients in years. This was true particularly of orthopaedic services for children. The number was small because, with increased prosperity, many patients were cared for by specialists in private practice and were no longer cared for in the wards where teaching of residents is carried out. How long this condition will continue, and what effect the possible plans for compulsory health insurance may have on these services, cannot be anticipated. It is the belief of the Joint Committee, however, that services in hospitals in which charitable care is given may be expected to occupy a less prominent part in educational programs than in years past, and more patients will be cared for by specialists in private practice. With this idea in view, The American Board of Orthopaedic Surgery passed the following resolution in January, 1945:

> "In special instances, with the approval of the Committee on Resident Training, the Board will recognize for not over two years' training in Orthopaedic Surgery periods of training in which the candidate continues work in a hospital service with part time assistantship to an Orthopaedic Surgeon certified by The American Board of Orthopaedic Surgery, provided that the major part of his time is spent by the candidate in the hospital service".

In order that recognition of this type of training may be obtained, a statement of the plan in each individual case should be filed with the Secretary of the Board.

One other phase of the general problem has been discussed by the Joint Committee. Its importance is recognized, and it is our intention to cooperate in every way possible in the planning of resident training in orthopaedic surgery in the permanent hospitals of the Army, Navy, and Veterans' Bureau. We have communicated with those who are planning the resident-training program in these hospitals, and we will do all we can to further the program. It is the opinion of the Committee that it will be to the advantage of all orthopaedic surgeons that training in orthopaedic surgery in such hospitals as the Army, Navy, and Veterans' Service designated as hospitals for resident training be recognized.

The Joint Committee intends to develop some means whereby it may stimulate the continuation of

all efforts to improve the quality of resident training. Some services may fail in this program. However, we cannot encourage large numbers to take this training without first making sure that the quality of resident training will be excellent.

The Joint Committee is aware, too, of the place this country must occupy in furnishing postgraduate training to students from foreign countries. While the next year or two will see facilities taxed to the utmost to care for returning American veterans, in the next two or three decades more graduate students from foreign countries will be receiving training in the United States, and plans must be developed to take care of them.

Two factors have delayed the placement of veterans in residencies; the solution of this difficulty has not yet been found. One is that many places on services are being held open for men whose training was interrupted to enter Military Service. The other is that many who have filed applications for residencies have not been able to tell the exact time of their release from Military Service. It is hoped that with the establishment of the Registry these difficulties can be reduced to a minimum.

Our efforts will continue. We appreciate the helpful spirit of those who have cooperated so generously in efforts to increase the number of approved residencies. Further help will be necessary both from those and from others who are developing new services now. It is our purpose to continue to develop services where facilities and personnel exist, and to urge continued improvement in all those services already established. There is room for improvement and we must progress. The whole future of orthopaedic surgery depends upon an adequate number of training programs with progressive, up-to-date plans for training new orthopaedic surgeons.

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REPORT FROM THE COMMITTEE ON POSTGRADUATE TRAINING IN ORTHOPAEDIC SURGERY AND THE OFFICE OF ORTHOPAEDIC INFORMATION

Following the January meeting of The American Academy of Orthopaedic Surgeons, the newly appointed Secretary took over the active work of this Committee from Dr. Ralph K. Ghormley, the Chairman, and set up at the Alfred I. duPont Institute in Wilmington, Delaware, an Office of Orthopaedic Information where a Registry has been established for orthopaedic residencies. Since the end of January, all communications coming to the Committee have been referred to this office for reply and action.

At the Academy meeting Dr. Ghormley reported that the files of the Committee at that time contained the names of 723 men desiring orthopaedic training. The lists of names had been compiled from the lists of applicants to the hospitals offering accredited training. These hospitals had received from ten to over 250 applicants each. During January a questionnaire was sent by Dr. Ghormley to each of these men in order to have on file with the Committee the following information: (1) a record of previous education, training, and experience prior to admission into Military Service; (2) a record of the training and experience received in Military Service; (3) the date of discharge from the Service; and (4) the applicant's desires concerning postwar orthopaedic training.

Four hundred and thirty-four of these questionnaires have been returned and grouped as follows: (1) men discharged from the Service and desirous of immediate training, 137 or 32 per cent.; (2) those desirous of training upon discharge in from three to nine months, 83 or 19 per cent.; (3) those recently inducted into the Service and desirous of training upon discharge, 48 or 11 per cent.; (4) those accepted for training, 140 or 32 per cent.; (5) those applying for training from foreign countries, including Canada, 18 or 4 per cent.; and (6) miscellaneous, 8 or 2 per cent. From these figures it can be seen that there are 220, or 51 per cent. of the total, who at the time of sending in the questionnaire desired orthopaedic training in 1946, but had not secured an appointment.

During the first week in February questionnaires were sent to the 110 single or combined orthopaedic services accredited for training, in order to obtain information on vacancies and the names of the appointees. The total number of accredited residencies is now 403. To date information has been received from ninety-two services, which have reported five vacancies, 365 appointments, and 290 names

of appointees. The eighteen services not yet heard from have thirty-eight residencies. On the basis of the services reporting, it can be stated that 99 per cent. of the appointments for training in accredited residencies in 1946 have been made, as of this date.

At the present time, this office has knowledge of eighty-eight civilian hospitals which have applied or are about to apply to the Council on Medical Education and Hospitals and The American Board of Orthopaedic Surgery for approval of orthopaedic training. These hospitals will have approximately 132 additional residencies, which, if approved, will increase the total accredited residencies to 535. Any hospital desiring tentative approval of its orthopaedic service should follow the procedure as outlined on page 585 of *The Journal of the American Medical Association*, March 2, 1946, "Temporary Approval of Residencies". The procedure is for the hospital to apply for tentative approval to the Secretary of the Council on Medical Education and Hospitals of the American Medical Association, and to the Secretary of The American Board of Orthopaedic Surgery, giving information concerning personnel, facilities, and educational program of the hospital service. Upon receipt of this application, the Secretary of the Board will take the necessary action to secure temporary approval by the Board for one year, and the Council will, during the course of the following year, arrange for an inspection of the hospital service by one of its representatives. If temporary approval is obtained, this may later be changed to permanent approval, provided that the Council and the Board give final approval to this training.

In addition to the accredited orthopaedic services in the civilian hospitals, there are now twenty Veterans Hospitals which have established, or are about to establish, orthopaedic residencies, and which according to the present plan for the operation of residencies in the Veterans Hospitals, should receive temporary approval of their residencies. In the selection from the applicants for these residencies, veterans will be given first consideration. During the next two years the Veterans Administration hopes to more than double the number of hospitals giving orthopaedic training. The following is a list of these twenty Veterans Hospitals, with the name of the Chairman of the Dean's Committee to whom letters concerning appointments for orthopaedic residencies should be addressed.

State	*Schools*	*Chairman of Dean's Committee*	*Location of Hospital*
California	California, Stanford	Dr. Howard C. Naffziger Medical School, Univ. of California San Francisco 22, Calif.	San Francisco
	Univ. of So. Calif.	Dean Burrell O. Raulston U. of So. Calif. School of Medicine 3551 University Ave. Los Angeles, California	Sawtelle
District of Columbia	George Washington, Georgetown	Dr. Walter A. Bloedorn Geo. Wash. School of Med. 1335 H St., Washington, D. C.	Mt. Alto
Indiana	Indiana Univ.	Dr. Matthew Winters, Sec. 23 E. Ohio St. Indianapolis, Ind.	Indianapolis
Illinois	Northwestern, Illinois, Loyola	Dr. J. Roscoe Miller Northwestern Univ. Med. School 303 E. Chicago Ave. Chicago, Ill.	1) Hines 2) Vaughn
Kentucky	Louisville	Dr. Arnold Griswold Univ. of Louisville School of Medicine 101 W. Chestnut St. Louisville, Kentucky	Nichols Gen. Hosp.
Maryland	Johns Hopkins, Maryland	Dr. Alan N. Chesney Johns Hopkins University School of Medicine 710 N. Washington St. Baltimore, Maryland *OR* Dr. Robert U. Patterson Univ. of Md. School of Medicine Baltimore 1, Maryland	Ft. Howard
Massachusetts	Boston Univ., Harvard, Tufts	Dr. C. Sidney Burwell Harvard Medical School 25 Shattuck St. Boston 15, Mass.	West Roxbury
Michigan	Wayne University	Dr. Hardy A. Kemp Wayne Univ. College of Med. Detroit 1, Mich.	Dearborn
Minnesota	Minn. University	Dr. Harold S. Diehl Univ. of Minn. Med. School Minneapolis 14, Minn.	Minneapolis

State	*Schools*	*Chairman of Dean's Committee*	*Location of Hospital*
New Hampshire	Dartmouth	Dr. Rolf C. Syvertsen Dartmouth Medical School Hanover, N. H.	White River Jct., Vt
New York	Columbia, Cornell, N. Y. U., N. Y. College of Medicine, L. I. College of Med.	Dr. Willard C. Rappleye 630 W. 168th St. New York 32, N. Y.	Bronx
Ohio	Western Reserve	Dr. Jos. T. Wearn Western Reserve Univ. School of Medicine 2109 Adelbert Rd. Cleveland, Ohio	Brecksville
Oregon	Oregon University	Dr. D. W. E. Baird Univ. of Oregon Med. School Portland 1, Oregon	Portland
Pennsylvania	Pittsburgh Univ.	Dr. Williams S. McEllroy Univ. of Pittsburgh School of Medicine Bigelow Blvd. Pittsburgh, Pa.	Aspinwall
Tennessee	Tenn. University	Dr. O. W. Hyman Univ. of Tenn. College of Medicine 874 Union Ave. Memphis 3, Tenn.	Memphis
	Vanderbilt Univ.	Dr. Ernest W. Goodpasture Vanderbilt Univ. School of Medicine 21st Ave., S., at Edgehill Nashville 4, Tenn.	Thayer Gen. Hosp.
Texas	Southwestern	Dr. Tinsley Harrison Southwestern Med. College 2211 Oak Lawn Dallas 4, Texas	Ashburn Gen. Hosp.
Utah	Utah University	Dr. H. L. Marshall Univ. of Utah School of Medicine Salt Lake City, Utah	Salt Lake City
Virginia	Med. Coll. of Virginia	Dr. Harry J. Warthen, Sec. Medical College of Va. Richmond, Virginia	McGuire Gen. Hosp.

The Army and Navy have now designated five hospitals each in which orthopaedic training will be given to doctors from the Medical Corps of the Regular Army and Regular Navy. These services are now in the process of being organized and established.

This office has also had many inquiries (1) from physicians discharged from the Armed Forces who have completed their orthopaedic training and wish information regarding suitable locations for practice, and (2) from Diplomates of the Board concerning available trained assistants. At the present time, there are many communities which apparently are either overcrowded or about to be overcrowded with returning orthopaedic surgeons, while many other communities are sorely in need of orthopaedic specialists. It is hoped that this office may acquire enough information on locations for practice in orthopaedic surgery to establish a Registry for them, and thus help this situation.

Any suggestions concerning how the work of this Committee can be made more effective will be greatly appreciated by the Chairman, Dr. R. K. Ghormley, the Secretary, and the whole Postgraduate Committee.

A. R. Shands, Jr., M.D., Secretary

March 23, 1946

FELLOWSHIPS IN ORTHOPAEDIC SURGERY OF THE NATIONAL RESEARCH COUNCIL

Fellowships in Orthopaedic Surgery, administered by the Medical Fellowship Board of the National Research Council, will again be available for the year beginning July 1, 1946. This series of fellowships, supported by a grant from the National Foundation for Infantile Paralysis, Inc., is designed to provide opportunities for training and research in those basic medical sciences which will be of particular value in furthering progress in the field of orthopaedic surgery.

These research fellowships are open to citizens of the United States and Canada who are graduates in medicine and who have completed one or more years of hospital experience in clinical surgery. They are intended for recent graduates, not yet professionally established, who are planning to specialize in orthopaedic surgery.

Further particulars concerning these fellowships may be obtained from the Secretary of the Medical Fellowship Board, National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

The American Public Health Association has recently designated the following institutions as accredited to give the degree of Master of Public Health (Diploma of Public Health in Canada) for the academic year 1946–47: Columbia University School of Public Health, Harvard University School of Public Health, The Johns Hopkins School of Hygiene and Public Health, University of California School of Public Health, University of Michigan School of Public Health, University of Minnesota School of Public Health, University of North Carolina School of Public Health, University of Toronto School of Hygiene, and Yale University School of Medicine, Department of Public Health.

UNITED STATES PUBLIC HEALTH SERVICE

Appointments to fill vacancies in the Reserve Corps of the United States Public Health Service are now being made, and examinations for Regular Corps appointments will be held in April and May.

Physicians, dentists, and nurses are needed immediately for duty in hospitals, in the Tuberculosis and Venereal Disease Control programs, and in other activities of the Public Health Service.

In making the announcement, Surgeon General Thomas Parran stated: "For the physician, the dentist, and the nurse, the Public Health Service is unique in the variety of opportunities it offers. Not only does the person have the opportunity for outstanding service to the nation in the growing field of Public Health, but the opportunities for professional growth and development are almost limitless. There is clinical work in Public Health Service hospitals throughout the country. The importance of medical research is being emphasized today more and more, and in the Public Health Service research opportunities exist in both laboratory and the field."

Those interested in either immediate appointment in the Reserve Corps, or in taking the examination for the Regular Corps, should request application forms of the Surgeon General, U. S. Public Health Service, Washington, D. C., Federal Security Agency.

SHRINERS' HOSPITALS FOR CRIPPLED CHILDREN

A nationwide, five-point program to expand and accelerate its fight against all crippling diseases affecting children has been set into action by the Shriners of North America.

The new program has been developed through a series of recent meetings sponsored by the Imperial Potentate, William H. Woodfield, Jr., of San Francisco, and other members of the Shriners' Imperial Council; and approved by Dr. J. Albert Key, of St. Louis, president of The American Orthopaedic Association; member surgeons of the Association who serve as chief surgeons of the fifteen Shriners' Hospitals for Crippled Children, located in various cities of the country; and W. Freeland Kendrick, Chairman of the National Board of Trustees of the Hospitals.

The five phases of the new plan are:

1. The granting of scholarships, to be known as The Fellowships of the Shriners' Hospitals for Crippled Children, in orthopaedic surgery, to outstanding, qualified medical students.

2. An annual appropriation will be granted for scholarships in orthopaedic nursing. These nurses, in turn, will instruct and give encouragement to other nurses interested in specializing in the crippled children's field.

3. The establishment of a research project to probe further the sources, methods of treatment, and prevention of all crippling diseases attacking children.

4. The expansion of present facilities and equipment of the fifteen Shriners' Hospitals now in operation and the establishment of new hospitals in other localities.

5. The establishment of convalescent homes in connection with all Shriners' Hospitals. The installation of recreational and occupational therapy courses to assure continuing physical improvement and self-development after healing has been completed.

The wide scope of charitable work carried on by the fifteen Hospitals is revealed in a statement by Mr. Kendrick that operating expenses for the current year will be in excess of $1,000,000. The Hospitals and endowments represent an investment of about $45,000,000, he said.

News Notes

THE AMERICAN ORTHOPAEDIC ASSOCIATION

The Annual Meeting of The American Orthopaedic Association will be held at Hot Springs, Virginia, June 27, 28, and 29, 1946, under the presidency of Dr. J. Albert Key. Headquarters will be at The Homestead Hotel.

The tentative program as submitted by the Program Committee is as follows:

THURSDAY, JUNE 27

Morning Session

The Calcaneovalgus Foot of Infancy.
Dr. J. E. M. Thomson, Lincoln, Nebraska.

The Definition of Human Locomotion on the Basis of Measurement, with Description of Oscillographic Method.
Dr. R. Plato Schwartz, Rochester, New York.

Hypermobile Flat Foot with Short Tendo Achillis. From Observations in the Canadian Army.
Dr. R. I. Harris, Toronto, Ontario, Canada.

Pre-Employment Back Examinations and Their Significance.
Dr. Steele F. Stewart, Honolulu, Hawaii.

A System for Splinting Hands for Radial, Ulnar, and Median Paralyses.
Dr. Sterling Bunnell, San Francisco, California.

Noon: Executive Session.

Afternoon Session

Symposium on the Intervertebral Disc.
Dr. Arthur G. Davis, Erie, Pennsylvania, *Chairman*.

FRIDAY, JUNE 28

Morning Session

Postgraduate Teaching in Orthopaedic Surgery.
Dr. Ralph K. Ghormley, Rochester, Minnesota.

Report of Committee on Infantile Paralysis.
Dr. Robert W. Johnson, Jr., Baltimore, Maryland, *Chairman*.

Newer Observations on the Experimental Contributions in Infantile Paralysis and Their Correlation to Pathological Facts. The Rationalization of Treatment of Infantile Paralysis on These Grounds.
Dr. Arthur Steindler, Iowa City, Iowa.

End Results of Bone-Grafting for Non-Union of the Carpal Navicular Based on the Study of 100 Cases.
Dr. Gordon Murray, F.R.C.S., Toronto, Ontario, Canada. (By invitation.)

President's Address.
Dr. J. Albert Key, St. Louis, Missouri.

Afternoon Session

The Evaluation of Cortical and Cancellous Bone as a Grafting Material; a Clinical and Experimental Study.
Dr. LeRoy C. Abbott, San Francisco, California.

Paper on a subject to be announced.
Mr. Harry Platt, F.R.C.S., Manchester, England.

Subtalar Arthrorisis for Certain Types of Flat Feet.
Dr. Allen F. Voshell,
Dr. Charles J. Basile,
Dr. William L. Waldrop,
Dr. Moses Gellman, Baltimore, Maryland.

Fracture-Dislocation of the Ankle with Fixed Displacement of the Fibula Behind the Tibia.
Dr. David M. Bosworth, New York, N. Y.

Medical Electronics. Electromyographic Studies of Muscle-Action Currents.
Dr. Nicholas S. Ransohoff, New York, N. Y.

SATURDAY, JUNE 29

Morning Session

Symposium on Treatment of Complications of Fractures of the Hip.
Dr. Philip D. Wilson, New York, N. Y., *Chairman.*

Noon: Executive Session.

It will be noted that there are fewer papers on the program this year. This change has been made in order to allow more time for discussion. It would be of help to the Program Committee if those who wish to discuss any of these papers would write to the Chairman, Dr. Lloyd T. Brown, 372 Marlborough Street, Boston, Massachusetts.

THE AMERICAN BOARD OF ORTHOPAEDIC SURGERY

Part I of the examinations will be given in New Orleans, Louisiana, May 3 and 4, 1946; in St. Louis, Missouri, and San Francisco, California, May 10 and 11, 1946; and in Philadelphia, Pennsylvania, May 17 and 18, 1946. They will not be repeated until the Spring of 1947.

Part II of the examinations will be given in Chicago, in January 1947, preceding the meeting of The American Academy of Orthopaedic Surgeons.

Correspondence and applications relative to Part I of the examinations should be sent to Dr. Guy A. Caldwell, 3503 Prytania Street, New Orleans 15, Louisiana. After July 1, 1946, all correspondence and applications for Part II should be sent to Dr. Francis M. McKeever, 1136 West Sixth Street, Los Angeles 14, California.

The Seventy-Fourth Annual Meeting of the **American Public Health Association** will be held in Cleveland, Ohio, the week of November 11, 1946.

The **American College of Surgeons** announces that arrangements have been completed for the holding of its Thirty-Second Clinical Congress at the Waldorf-Astoria, New York, September 9 to 13, inclusive. Plans include the usual extensive program of demonstrations, scientific sessions, panel discussions, symposia, forums, Hospital Standardization Conference, medical motion pictures, business meetings, and educational and technical exhibits, which will be held in the headquarters hotel, and operative and non-operative clinics in the local hospitals.

BARUCH COMMITTEE ON PHYSICAL MEDICINE

To advance and encourage research, teaching, and training in the field of physical medicine—and to direct the benefits of this branch of medicine to the rehabilitation of persons maimed in war, industry, or by illness—Bernard M. Baruch, in 1944, made an initial grant of $1,100,000 to the Baruch Committee on Physical Medicine.

The first annual report of the Committee, prepared by the Medical Director, Dr. Frank H. Krusen, of the Mayo Clinic, has outlined the progress in attaining the objectives of Mr. Baruch's endowment.

Eleven medical schools received funds from the original grants. The report shows the amount allocated to each school, and summarizes the activities of the year in the specific institutions,—such as the appointment of directors of the program and professors of physical medicine, creation of courses leading to a degree in occupational and physical therapy, equipment of new laboratories for research, and plans for research in varied fields of science.

NEW CATALOGUE OF UNITED STATES GOVERNMENT FILMS FOR SCHOOLS AND INDUSTRIES

This catalogue, just published, contains for the first time a complete list of all United States Government sound films (sixteen millimeter) and filmstrips (thirty-five millimeter). It includes 466 motion pictures and 432 filmstrips of the United States Office of Education, as well as training films and other types of educational film produced by the Navy, War Department, Department of Agriculture, and United States Public Health Service.

The library of films shows the completed production program of the Department of Visual Aids, United States Office of Education, and is the result of the cooperative efforts of many individuals. Twenty-three visual and technical specialists planned and supervised the productions, which were made by thirty-six motion-picture companies.

Films helped in a small measure to win the war, as training time was shortened and production was increased. Educators regard them as of the greatest use for peacetime teaching and training in schools and industry.

The catalogue may be obtained from Castle Films, Incorporated, distributors, 30 Rockefeller Plaza, New York, N. Y.

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Thirteenth Annual Convention of The American Academy of Orthopaedic Surgeons was held at the Palmer House, Chicago, January 19, 20, 21, 22, and 23, 1946, under the presidency of Dr. E. Bishop Mumford, of Indianapolis. The first day was devoted to registration; the attendance was larger than at any previous meeting, with 1223 Fellows and guests registering. An excellent program of scientific motion pictures was presented on the first day and at definite periods throughout the meeting. Opportunity was given at various times to visit the many scientific and technical exhibits.

Instructional Courses, arranged by Dr. J. E. M. Thomson, were offered on the second day of the Convention, and the morning of the third day was devoted to a symposium on Degenerative Hip Disease. An Instructional Course dinner was given on the evening of January 19, followed by a panel discussion of The Painful Shoulder and Upper Extremity.

The following papers were read and discussed at the Scientific Sessions, on January 21, 22, and 23:

Monday, January 21

Afternoon Session

Spasmodic Torticollis: Severe Organic Type Treated by Combined Operation, Rhizotomy, and Fusion.
Dr. Alfred W. Adson, Rochester, Minnesota. (By invitation.)
Dr. H. Herman Young, Rochester, Minnesota.
Dr. Ralph K. Ghormley, Rochester, Minnesota.
Discussion: Dr. Loyal Davis, Chicago, Illinois. (By invitation.)
Dr. Lloyd T. Brown, Boston, Massachusetts.

Sympathetic Block of the Stellate Ganglion: Its Applications in Orthopaedic Conditions.
Dr. Guy A. Caldwell, New Orleans, Louisiana.
Dr. T. F. Broderick, Jr., Boston, Massachusetts. (By invitation.)
Dr. R. M. Rose, New Orleans, Louisiana. (By invitation.)
Discussion: Dr. J. E. M. Thomson, Lincoln, Nebraska.
Dr. Edward L. Compere, Chicago, Illinois.

The Operative Treatment of Scoliosis—A Corrective Appliance Supersedes the Bent Cast.
Dr. Walter P. Blount, Milwaukee, Wisconsin.
Dr. Albert C. Schmidt, Milwaukee, Wisconsin.
Discussion: Dr. Joseph S. Barr, Boston, Massachusetts.
Dr. H. R. McCarroll, St. Louis, Missouri.

The Multiple Innervation of Limb Muscles in Man.
Dr. W. Henry Hollinshead, Durham, North Carolina. (By invitation.)
Dr. J. E. Markee, Durham, North Carolina. (By invitation.)
Discussion: Dr. Eben J. Carey, Milwaukee, Wisconsin.
Dr. R. Plato Schwartz, Rochester, New York.

Knee Fusion by Three-Flanged Nail.
Dr. David M. Bosworth, New York, N. Y.
Discussion: Dr. Allen F. Voshell, Baltimore, Maryland.
Dr. E. W. Ryerson, Chicago, Illinois.

Tuesday, January 22

Morning Session

Plastic Operations on the Hip with Special Reference to Results from Arthroplasty with Cups of Methyl Methacrylate.
Dr. Paul H. Harmon, Milton, West Virginia.
Discussion: Dr. Lenox D. Baker, Durham, North Carolina.
Dr. M. N. Smith-Petersen, Boston, Massachusetts.

Experiences with the Brittain Ischiofemoral Arthrodesis.
Dr. Joseph A. Freiberg, Cincinnati, Ohio.
Discussion: Dr. Carl C. Chatterton, St. Paul, Minnesota.
Dr. Robert A. Knight, Memphis, Tennessee.
Dr. David M. Bosworth, New York, N. Y.

Treatment of Congenital Dislocation of the Hip.
Dr. Edward L. Compere, Chicago, Illinois.
Dr. William J. Schnute, Chicago, Illinois. (By invitation.)
Discussion: Dr. H. R. McCarroll, St. Louis, Missouri.
Dr. E. W. Ryerson, Chicago, Illinois.

Mobilization of Metacarpophalangeal Joints—Capsulotomy and Arthroplasty.
Captain Samuel B. Fowler, M.C., A.U.S. (By invitation.)
Discussion: Dr. Sterling Bunnell, San Francisco, California.
Dr. J. S. Speed, Memphis, Tennessee.

Psychological Problems Observed in Military Orthopaedic Surgery.
Major J. Vernon Luck, M.C., A.U.S.
Discussion: Dr. Alan DeForest Smith, New York, N. Y.
Dr. Arthur Steindler, Iowa City, Iowa.

Factors Influencing Callus Formation in Open Fixation of Fractures.
Dr. Jean Verbrugge, Antwerp, Belgium. (By invitation.)

Progress Report of the Joint Committee on Postgraduate Training in Orthopaedic Surgery.
Dr. Ralph K. Ghormley, Rochester, Minnesota, *Chairman.*

Afternoon Session

Treatment of Compound, Comminuted Fractures Involving the Elbow Joint by Resection of the Fragments.
Dr. J. T. Nicholson, Philadelphia, Pennsylvania.
Discussion: Dr. Jean Verbrugge, Antwerp, Belgium. (By invitation.)

Restoration of Bone Strength with Reinforcement Bone Grafts.
Dr. George K. Carpenter, Nashville, Tennessee.
Dr. Robert T. Rosenfeld, Highland Park, Illinois. (By invitation.)
Major Karl F. Mech, M.C., A.U.S.
Discussion: Dr. W. W. Plummer, Buffalo, New York.
Colonel Robert H. Kennedy, M.C., A.U.S.

Reconstruction of Defects of the Tibia and Femur with Apposing Massive Grafts from the Affected Bone. A Preliminary Report.
Major John J. Flanagan, M.C., A.U.S.
Captain Henry S. Burem, M.C., A.U.S. (By invitation.)
Discussion: Dr. J. S. Speed, Memphis, Tennessee.
Dr. James A. Dickson, Cleveland, Ohio.

Skin-Grafting in the Treatment of Osteomyelitis.
Lt. Colonel Robert P. Kelly, M.C., A.U.S. (By invitation.)
Discussion: Dr. Ralph K. Ghormley, Rochester, Minnesota.
Colonel Leonard T. Peterson, M.C., U. S. Army.

The Overseas Treatment of Compound Fractures of the Long Bones.
Dr. George O. Eaton, Baltimore, Maryland.
Discussion: Dr. Edwin F. Cave, Boston, Massachusetts.
Dr. W. H. McGaw, Cleveland, Ohio.

WEDNESDAY, JANUARY 23

Morning Session

Neurectomy to Produce Atrophy of Amputation Stump.
Dr. Alfred O. Adams, Spokane, Washington.
Discussion: Lt. Colonel Clinton L. Compere, M.C., A.U.S.

Conservation of Short Amputation Stumps by Utilization of Tendon Section.
Lt. Colonel Harry C. Blair, M.C., A.U.S.
Major Harry D. Morris, M.C., A.U.S.

The Technique of the Syme Amputation.
Major R. H. Alldredge, M.C., A.U.S.
Lt. Colonel T. C. Thompson, M.C., A.U.S.
Discussion: Major Harry C. Morris, M.C., A.U.S.
Dr. William E. Gallie, Toronto, Ontario, Canada.

A Five-Point Plan for the Rehabilitation of the Arm Amputee.
Captain H. H. Kessler, M.C., U.S.N.R.
Discussion: Dr. Harold Conn, Akron, Ohio.
Lt. Colonel Ernest E. Myers, M.C., A.U.S.

Afternoon Session

Disability Evaluation for the Hand.
Major Donald B. Slocum, M.C., A.U.S.

Captain Donald R. Pratt, M.C., A.U.S.
Discussion: Major L. D. Howard, M.C., A.U.S.
Dr. Earl D. McBride, Oklahoma City, Oklahoma.

The Use of Cellophane in Reconstructive Orthopaedic Surgery.
Dr. Duncan C. McKeever, Houston, Texas.
Discussion: Major Louis W. Breck, M.C., A.U.S.
Dr. Philip Lewin, Chicago, Illinois.

Transplantation of Tendons through Preformed Gliding Channels.
Major J. E. Milgram, M.C., A.U.S.
Discussion: Dr. Robert D. Schrock, Omaha, Nebraska.
Dr. Leo Mayer, New York, N. Y.

The Repair of Knee Ligaments by Cutis-Graft Transplants.
Dr. Randolph L. Anderson, Charleston, West Virginia.
Discussion: Dr. H. Page Mauck, Richmond, Virginia.
Dr. Emil D. W. Hauser, Chicago, Illinois.

Semidelayed Bone Graft for Subcapital Fractures of the Hip.
Dr. Arch F. O'Donoghue, Sioux City, Iowa.
Dr. Edmund S. Donohue, Sioux City, Iowa. (By invitation.)
Discussion: Dr. Walter P. Blount, Milwaukee, Wisconsin.
Dr. Austin T. Moore, Columbia, South Carolina.

The Annual Dinner, at which President Mumford presided and delivered his Presidential Address, was held Tuesday evening, January 22. Part of the program for the evening consisted of the announcement of the scientific exhibits meriting awards and certificates, as follows:

Gold-Medal Awards

For Originality of Presentation; to the Medical Officers of Camp Carson, Colorado; Title of exhibit, "Trench Foot".

For Scientific Value; to Dr. John Lyford, III, and Dr. Robert W. Johnson, Jr., Baltimore, Maryland; Title of exhibit, "Granuloma Inguinale as a Cause of Arthritis and Osteomyelitis".

For Clinical Value; to Dr. Charles J. Basile, Dr. William L. Waldrop, Dr. Allen F. Voshell, and Dr. Moses Gellman, Baltimore, Maryland; Title of exhibit, "Subtalar Arthrorisis for Certain Types of Flat-Foot".

Honorable Mention

For Originality of Presentation; to Dr. H. H. Young and Dr. Ralph K. Ghormley, Rochester, Minnesota; Title of exhibit, "Injuries Due to Farm Accidents".

For Scientific Value; to Major J. E. Milgram, M.C., A.U.S.; Title of exhibit, "Operative Creation of New Gliding Channels for Muscle Bellies and Tendons".

For Clinical Value; to Commander Edward H. Crosby, M.C., U.S.N.R.; Title of exhibit, "A New Surgical Procedure for Repair of Recurrent Dislocation of the Shoulder".

Honorable Mention for "Gadgets and New Ideas"

To Dr. George Dawson, Florence, South Carolina, for his "Motor-Driven Screw-Holder-Screw-Driver".

To Dr. J. Warren White, Greenville, South Carolina, for his "Shelf-Bracket Well-Leg Traction".

To Dr. Robert T. Schrock, Omaha, Nebraska, for his "Skeletal Neck Brace".

To Dr. G. Mosser Taylor and Dr. Alonzo J. Neufeld, Los Angeles, California, for their "Femoral Nail Plate", "Special Retractor for Spinal Surgery", and "Method of Inserting Skeletal Traction to the Fingers".

Newly elected Fellows presented at the Meeting were:

Dr. John Hamilton Allan, Philadelphia, Pennsylvania
Dr. George Guy Bailey, Boston, Massachusetts
Dr. Dorsey K. Barnes, Dallas, Texas
Dr. Henry Hilliard Beckering, Dallas, Texas
Dr. Carl Berg, Washington, D. C.
Dr. William Harold Bickel, Rochester, Minnesota
Dr. John Robert Black, Los Angeles, California
Dr. Arthur Irving Blieden, New York, N. Y.
Dr. F. Bert Brown, Savannah, Georgia

Dr. Theodore Waggoner Bywaters, Dallas, Texas
Dr. Gene D. Caldwell, Shreveport, Louisiana
Dr. Lewis N. Cozen, Los Angeles, California
Dr. Burr Harding Curtis, Hartford, Connecticut
Dr. George Robert Dawson, Jr., Florence, South Carolina
Dr. Ernst Dehne, Wilmette, Illinois
Dr. George Lane Dixon, Tucson, Arizona
Dr. Francis Harold Downing, Fresno, California
Dr. Louis Henry Edmunds, Seattle, Washington
Dr. Norton Sheldon Freedman, Hato Rey, Puerto Rico
Dr. Charles W. Goff, Hartford, Connecticut
Dr. Malcolm B. Hadden, Berkeley, California
Dr. A. Scott Hamilton, Monroe, Louisiana
Dr. Clement Richard Hanlon, Bethlehem, Pennsylvania
Dr. S. Sverre Houkom, Duluth, Minnesota
Dr. Robert Tasker Humphries, Clarksburg, West Virginia
Dr. Lewis L. Huston, Longmeadow, Massachusetts
Dr. John B. Kelley, Worcester, Massachusetts
Dr. Robert Allen Knight, Memphis, Tennessee
Dr. Lawrence Robert Leidig, Santa Monica, California
Dr. Paul Rogers Lipscomb, Rochester, Minnesota
Dr. James Lytton-Smith, Phoenix, Arizona
Dr. John Laing McDonald, Toronto, Ontario, Canada
Dr. Robert Talbot McElvenny, Chicago, Illinois
Dr. Paul B. Magnuson, Chicago, Illinois
Dr. Eugene James Morrissey, Bethlehem, Pennsylvania
Dr. Robert M. O'Brien, St. Louis, Missouri
Dr. Robert Thornton Percival, Forest Hills, New York
Dr. Thomas H. Peterson, Boston, Massachusetts
Dr. Robert R. Rix, Manchester, New Hampshire
Dr. Peter-Cyrus L. Rizzo, Cambridge, Ohio
Dr. Harold H. Sankey, Pittsburgh, Pennsylvania
Dr. L. Stanley Sell, Oklahoma City, Oklahoma
Dr. Mario E. Stella, New York, N. Y.
Dr. Clyde Beverly Trees, Dallas, Texas
Dr. Harold Unger, Kansas City, Missouri
Dr. Frederick H. Vom Saal, New York, N. Y.
Dr. Richey L. Waugh, Boston, Massachusetts
Dr. Herman Leslie Wenger, New York, N. Y.

Dr. Jean Verbrugge, of Antwerp, Belgium, was elected Corresponding Member.

The First Executive Session was held at noon on Monday. At the Second Executive Session, held at noon on Wednesday, new officers and committee members for the year were elected.

The new officers of The Academy are:

President: Dr. J. E. M. Thomson, Lincoln, Nebraska
President-Elect: Dr. Rex L. Diveley, Kansas City, Missouri
Vice-President: Dr. Mather Cleveland, New York, N. Y.
Secretary: Dr. Myron O. Henry, Minneapolis, Minnesota
Treasurer: Dr. Fremont A. Chandler, Chicago, Illinois
Librarian-Historian: Dr. Edward L. Compere, Chicago, Illinois

The Fourteenth Annual Convention will be held in Chicago, in January 1947.

Current Literature

EXTENSILE EXPOSURE APPLIED TO LIMB SURGERY. Arnold K. Henry, M.B., Dublin; M.Ch. (Hon.), Cairo; F.R.C.S.I. Edinburgh, E. and S. Livingstone Ltd.; Baltimore, The Williams and Wilkins Company, 1945. $7.00.

In this book of 180 pages, illustrated with skill and care, Henry not only describes the surgical exposures by which extremity operations may be performed, but elucidates the philosophy underlying physiological dissection by the surgeon in reaching a given region. In addition, the approaches are so conceived that they may readily be extended (hence "extensile"), while at the same time there is maximum (and adequate) provision for safety against inadvertent surgical damage to important structures. The approaches, conceived with originality and a perspective based on profound knowledge of anatomy, are of proven worth, and appear in book form after modification under the stress of use in many lands by many surgeons with varying degrees of skill and experience.

Some of the approaches the author has described in a previous book, long a classic, (Exposures of Long Bones and Other Surgical Methods, New York, William Wood and Company, 1927). Valuable as is the earlier work, the present volume is so much more lucid that it is in truth a new and different book.

The work can scarcely be recommended too highly. It is hard to see how one can do the best orthopaedic operating without a knowledge of its contents.

HEY GROVES' SYNOPSIS OF SURGERY. Edited by Cecil P. G. Wakeley, C.B., D.Sc., F.R.C.S., F.R.S.E., F.A.C.S., F.R.A.C.S. Ed. 12. Bristol, John Wright & Sons, Ltd.; Baltimore, The Williams and Wilkins Company, 1945. $6.00.

In 1908 the great British surgeon, Ernest W. Hey Groves, edited "Synopsis of Surgery". In the preface to the first edition, he wrote:

"The present volume is an attempt to make an epitome of the salient facts in surgical practice, and to place these facts in such a manner that they may most easily and rapidly be referred to or revised. It has been compiled almost entirely from notes made by the author in preparing students for examinations.

"It is of course obvious that the large works cannot be dispensed with; but after a student has carefully read through a complete text-book, which ought to be done at the time he is actually engaged in ward and out-patient work, he may find this Synopsis an aid to his memory in retaining a vast array of facts in an orderly manner."

Not only the student, but also the busy practitioner has found this Synopsis a compendium of knowledge of surgical diagnosis and treatment and of practical value because of its concise form and methodical arrangement.

Periodically, the Synopsis has been thoroughly revised; the twelfth edition was almost completed at the time of Mr. Hey Groves' death. The work was taken up and completed by his friend, Cecil P. G. Wakeley.

This edition represents a careful and thorough revision. The inclusion of penicillin and the sulfonamides has necessitated a complete rewriting of several chapters. Many new developments in surgical technique are presented in this latest edition.

It is to be hoped that new editions of the work will continue to appear from time to time.

SURGICAL TREATMENT OF THE MOTOR-SKELETAL SYSTEM. Frederic W. Bancroft, A.B., M.D., F.A.C.S., and Clay Ray Murray, M.D., F.A.C.S., Editors. Philadelphia, London, and Montreal, J. B. Lippincott Company, 1945. $20 a set (two volumes).

The broad subject of surgical treatment is dealt with in this two-volume publication from the point of view of presenting an up-to-date picture of operations involving the motor-skeletal system. The scope of the work is not limited to surgical technique, however, but includes a discussion of the indications for operation, the postoperative treatment, and the prognosis. Alternative operative procedures are described for certain conditions.

Part I deals with congenital and acquired deformities; paralytic disorders; affections of back, muscles, fasciae, tendons, bursae, and ganglia; new growths; diseases of bones and joints; and amputations. Part II includes fractures and dislocations; sprains, sprain-fractures, muscle and tendon injuries; birth injuries of the motor-skeletal system; and military surgery.

The work represents the combined efforts of forty-three authors, each of whom has contributed a chapter or section. If the statements of an author are incomplete or deal with controversial subjects, amplifications and comments are often interpolated by the editors. This author-editor relationship, in its collaborative effect, adds materially to the value of the work.

A short list of references follows each section, but the books are intended for general use rather than as reference volumes.

THE 1945 YEAR BOOK OF INDUSTRIAL AND ORTHOPEDIC SURGERY. Charles F. Painter, M.D., Editor. Chicago: The Year Book Publishers, 1946. $3.00.

The value of a year book depends primarily upon the wisdom with which the material is selected. The careful choice of articles on orthopaedic subjects by the Editor and the excellent abstracts of the articles combine to make this book of value, especially to those who have not been able to follow the current literature in the field. It gives a clear summary of the important developments during the year in the field of orthopaedic surgery.

The last section is devoted to a résumé of the literature on industrial medicine and surgery. In this section have been emphasized some of the health hazards introduced by war.

DR. W. C. RÖNTGEN. Otto Glasser, Ph.D. Springfield, Illinois, Charles C. Thomas, 1945. $4.50.

Under the combined sponsorship of the American Roentgen Ray Society, the Radiological Society of North America, and the American College of Radiology, this book appeared in 1945—which is both the hundredth anniversary of Röntgen's birth and the fiftieth anniversary of his discovery of roentgen rays—as a condensation of Dr. Glasser's comprehensive *Wilhelm Conrad Röntgen and The Early History of the Roentgen Rays*, published in 1934. The original work was developed by Dr. Glasser with the authority born of native understanding, education, and exhaustive care in preparation, as well as his unusual access to most important material. This smaller book is exceedingly readable; it consists of a delightful biography, a chronological survey of Röntgen's life and achievements, the translation of his classic *Communications*, and some interesting new illustrations. Both professional and lay readers will find enjoyment and benefit in learning anew of this memorable man, one of the greatest physicists the world has known, who has done much to lighten the ills of the human race by helping to make the practice of medicine a science as well as an art.

MEN WITHOUT GUNS. DeWitt Mackenzie. Foreword by Major General Norman T. Kirk, M.C. Philadelphia and Toronto, The Blakiston Company, 1945. $5.00.

In "Men Without Guns" are grouped more than a hundred reproductions of paintings by twelve distinguished artists who were assigned to different theaters of the War. Their purpose was to give to people at home an account of how the health of their boys in various zones of conflict was being safeguarded and of how the wounded were cared for.

The paintings they produced did more than that; they were a record of the work of the Army Medical Department in many lands. They are not in any sense a history of Army medicine, but rather the artists' impressions of what they saw under all conditions of war. They pay high tribute to the corpsman and to the Army nurse, as well as to the doctors in all links of the chain of the Army program from the battalion aid station through the clearing station, the evacuation hospital, the general hospital, the embarkation hospital, hospital plane or hospital ship, the debarkation hospital, and finally the general hospital at home.

The text is an interesting account of experiences on the different fronts—the Southwest Pacific, Italy, Normandy, and Burma. It is written for the layman, not the medical man. However, the book will be remembered primarily for the reproductions of great paintings, which faithfully portray the work of the Medical Corps.

In his foreword, Surgeon General Norman T. Kirk said: "No artist ever had a more worthy subject for his brush than did the twelve distinguished painters whose canvases on Army Medicine are reproduced in this volume.

"Unequivocally and without fear of contradiction, I say with pride and reverence that one of the greatest contributions to victory has been made by the doctors, nurses, and enlisted men of the Army Medical Department. Without their tireless devotion to duty, their courage and complete disregard for self-safety, the Medical Department would not be able to point today to a record of achievement unmatched in the long history of warfare."

END-RESULTS IN THE TREATMENT OF HYPERPARATHYROIDISM. Roy D. McClure and Conrad R. Lam. *Annals of Surgery*, **121**: 454–469, 1945.

In this small series are examples of all clinical types of hyperparathyroidism: classic von Recklinghausen's disease; osteoporosis, with and without renal stones; renal stones alone; and a type which has been called acute parathyroid poisoning. Only one of the six patients did not have surgical treatment, and he died with acute parathyroid intoxication. Adenomata were removed from the other five patients. One died four months later in an hypoparathyroid state. The four remaining patients have now been followed for periods ranging from four to eight years, and they appear to be normal.—*Paul P. Swett, M.D., Bloomfield, Connecticut.*

INTERVERTEBRAL DISK LESIONS ARE THE MOST COMMON CAUSE OF LOW BACK PAIN WITH OR WITHOUT SCIATICA. J. Albert Key. *Annals of Surgery*, **121**: 534–544, 1945.

With customary forthrightness, the author sets forth the thesis that "The conditions which we have called low back strains and classified as idiopathic low back pain are lesions of the intervertebral disk

in this area." It is pointed out that the operative cure of disc lesions is an elective major surgical procedure which should not be undertaken lightly. Instead, it must be recognized that the surgeon's duty is to relieve the patient's symptoms in the simplest and safest manner. If conservative means fail, the surgeon can resort to operative removal of the disc with reasonable assurance of success.

The article is provocative and controversial, but it clearly sets forth the present views of a competent surgeon concerning a subject of great clinical importance.—*Paul P. Swett, M.D., Bloomfield, Connecticut.*

QUADRICEPSPLASTY. T. Campbell Thompson. *Annals of Surgery*, **121**: 751–755, 1945.

This procedure rests upon the sound basis that the function of a tendon depends upon the absence of scarring between the tendon and the surrounding structures. In the operation to restore flexion to the knee, the joint is forcibly flexed to 90 degrees without lengthening the rectus femoris muscle. If either of the vastus muscles is badly scarred, it is isolated and removed from the rectus by making a new intermuscular septum of soft tissues. The intact rectus femoris permits early motion and an early resumption of full, active extension. In selected cases, this procedure has certain advantages over Bennett's original operation for quadriceps lengthening.—*Paul P. Swett, M.D., Bloomfield, Connecticut.*

BONE SARCOMA IN POLYOSTOTIC FIBROUS DYSPLASIA. Bradley L. Coley and Fred W. Stewart. *Annals of Surgery*, **121**: 872–881, 1945.

So far as is known, this is the first report of the occurrence of malignant disease resulting from fibrous dysplasia of bone. Since this syndrome is being recognized with increasing frequency, the possibility of the late appearance of bone sarcoma is important. It is concluded on the basis of two carefully observed cases that polyostotic fibrous dysplasia is one of a group of bone diseases in which malignant tumors occasionally develop. The histological appearance was identical; the pattern was non-bone-forming pleomorphic spindle-cell and giant-cell tumors. Metastases were apparently produced in both cases. The response to radiotherapy was marked by unusual and unexpected relief from pain and by some evidence of bone regeneration.—*Paul P. Swett, M.D., Bloomfield, Connecticut.*

TRAUMATIC OSTEOMYELITIS: THE USE OF SKIN GRAFTS—PART I. TECHNIC AND RESULTS. Robert P. Kelly, Louis M. Rosati, and Robert A. Murray. *Annals of Surgery*, **122**: 1–11, 1945.

These authors report on the satisfactory use of skin-grafting in the treatment of osteomyelitis. The technique is fully described. Emphasis is given to the need for a thorough preliminary saucerization and the equal need for applying the grafts so that compression can be distributed evenly to all of them. On the basis of approximately 100 cases treated by the method described, it is believed that this is a safe form of treatment and that it will give beneficial results in the majority of instances. While occasional reports of the successful use of skin grafts in the treatment of osteomyelitis have appeared in the literature for many years, the method has not received wide use. The authors hope that this encouraging report will stimulate others to apply this treatment.—*Paul P. Swett, M.D., Bloomfield, Connecticut.*

MONO-ARTICULAR OSTEO-ARTHRITIS OF THE HIP. TREATMENT BY ACID INJECTION. W. Grant Waugh. *British Medical Journal*, **1**: 873–874, 1945.

Over a nine-year period, the author has employed intra-articular acid injection in the treatment of over 1,200 cases of various types of arthritis, including osteo-arthritis, traumatic arthritis, "menopausal" arthritis, and rheumatoid arthritis in the stage of residual deformity, with the idea of reducing alkalinity of the synovial fluid. Although statistics are lacking, he estimates that over 70 per cent. of the patients have been relieved of pain and have sufficient restoration of function to permit normal occupation.

He tried the same form of treatment in cases of mono-articular arthritis of the hip joint, which had previously proved resistant to most forms of therapy. Of 142 cases examined by the author, 108 have been treated by weekly injections into the joint of from 15 to 20 cubic centimeters of a solution of lactic acid (pH 5.8), together with procaine. This was followed by gradual manipulation and exercises, without weight-bearing. Follow-up results were obtained in only twenty-six of the patients; of this group, between 50 and 60 per cent. are able to carry on their normal occupations.

Loss of joint space, indicating extreme destruction of the articular cartilage, is the chief contraindication to this form of treatment.

NYLON BONE SUTURE. M. John Rowe. *Surgery*, **18**: 764–768, 1945.

Nylon is a strong, inert, semi-elastic, non-organic, radiolucent suture material which has been found to be well tolerated by the tissues. Rowe reports satisfactory results with the use of nylon bone sutures. These sutures have been used successfully in the repair of acromioclavicular separations, hallux valgus, and fractured patellae; as intertarsal sutures following reconstruction operations; and in the maintenance of position of loose fragments in compound fractures of the long bones.—*Edward L. Compere, M.D., Chicago, Illinois.*

ROENTGENOGRAPHIC INTERPRETATION OF WHAT CONSTITUTES ADEQUATE REDUCTION OF FEMORAL NECK FRACTURES. Robert T. McElvenny. *Surgery, Gynecology, and Obstetrics*, **80**: 97–106, 1945.

The author has evaluated from his own experience various ways of dealing with intracapsular fractures of the hip. Certain facts have been obtained from his study of failures, and these facts are used in formulating criteria of roentgenographic interpretation at the time of reduction and nailing of fractures. All failures have occurred in hips which have been reduced imperfectly,—that is, the neck fragment has not been placed well under and well inside the head fragment. McElvenny feels that accurate placement is absolutely necessary in order that fixation may act as a guide to allow the head to settle on the neck in a position in which the weight thrust is applied directly to the fracture site, without shearing or torsion forces being exerted on the fixation material.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

RAPID REPAIR OF DEFECT OF FEMUR BY MASSIVE BONE GRAFTS AFTER RESECTION FOR TUMORS. Dallas B. Phemister. *Surgery, Gynecology, and Obstetrics*, **80**: 120–127, 1945.

By means of bone-grafting, amputation was avoided in two cases of locally resected bone tumors of the lower end of the femur. Two tibial grafts, each between two-fifths and one-half the circumference of the shaft and from seven to eleven inches in length, were used to bridge the defect. The grafts were part onlay and part intramedullary, with fixation by threaded wires at each end. Firm bony union was obtained in about twelve weeks in one case and in five months in the other case. At the end of three and one-half years, both grafts had been transformed into tubular bone.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

ASEPTIC NECROSIS OF THE CAPITAL FEMORAL EPIPHYSIS FOLLOWING ADOLESCENT EPIPHYSEOLYSIS. Robert D. Moore. *Surgery, Gynecology, and Obstetrics*, **80**: 199–204, 1945.

Moore reviews the literature dealing with descriptions of femoral epiphyseal pathological lesions and gives a detailed account of the macroscopic and microscopic findings in two cases of slipped femoral epiphysis. The article is a purely descriptive recording and offers no new explanation as to cause.

This paper may be summarized briefly, as follows: After interruption of the blood supply to the epiphysis in adolescents, the overlying articular cartilage may remain viable or may undergo partial or complete necrosis. In either case, subsequent degenerative and reparative changes apparently result in reduction of the depth of the articular cartilage, as occurs in the adult with aseptic necrosis of the head following fracture of the neck of the femur. This is in contrast to the changes seen in Legg-Perthes disease, where rapid growth of the living articular cartilage compensates for any absorption or ossification of the cartilage which takes place after revascularization of the ossification center. Under these circumstances, the depth of the articular cartilage usually increases.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

The Journal wishes to acknowledge receipt of the following publications, which were sent to the Editorial Department:

Anais Paulistas de Medicina e Cirurgia (São Paulo, Brasil), **50**: Nos. 3, 4, 5, e 6, 1945.
Analecta Medica (México), **6**: No. 3, 1945.
The Bethesdan (Cincinnati, Ohio), **46**: No. 4, 1945.
Boletím do Sanatório São Lucas (São Paulo, Brasil), **7**: Nos. 3, 4, 5, e 6, 1945.
Boletín del Colegio Médico de la Habana (Cuba), **8**: Núm. 12, 1945; **9**: Núm. 1, 1946.
The Bulletin of the U. S. Army Medical Department (Carlisle Barracks, Pennsylvania), **5**: Nos. 1 and 2, 1946.
Harper Hospital Bulletin (Detroit, Michigan), **3**: No. 3, 1945.
Médica (Matanzas, Cuba), **4**: Núm. 6, 1945.
The National Foundation for Infantile Paralysis (New York, N. Y.), National Foundation News, **5**: No. 1, 1946.
The Physiotherapy Review (New York, N. Y.), **25**: No. 6, 1945; **26**: No. 1, 1946.
Radiography and Clinical Photography (Rochester, N. Y.), **21**: No. 3, 1945.
Revista Médica Municipal (Rio de Janeiro, Brasil), **6**: Núm. 2, 1945.
Sanidad y Beneficencia Municipal (Habana, Cuba), **5**: Núm. 2, 1945.
Santa Casa de Misericordia de Itatiba (Brasil), Relatorio da Diretoria, 1944.
Sociedad de Cirurgía de Córdoba (Argentina), Boletines y Trabajos, **6**: Nos. 5 y 6, 1945.
United States Public Health Service (Washington, D. C.), Public Health Bulletin No. 291: "A Medical Study of the Effect of TNT on Workers in a Bomb and Shell Loading Plant" and "Report of Fatal Case of Aplastic Anemia"; The Journal of Venereal Disease Information, **26**: No. 12, 1945; **27**: Nos. 1 and 2, 1946; Public Health Reports, **60**: Nos. 51 and 52, 1945; **61**: Nos. 1 to 11, 1946; Supplements, Nos. 187, 188, and 189.